Solar® 9500
Information Monitor
Operator's Manual

Software Version 3

2001085-059 Revision C

GE Medical Systems
Information Technologies

gemedical.com

NOTE: Information in this manual only applies to Solar 9500 Information Monitor software version 3. It does not apply to earlier software versions. Due to continuing product innovation, specifications in this manual are subject to change without notice.

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CE Marking Information

CE

Compliance

The Solar 9500 Information Monitor bears CE mark CE-0459 indicating its conformity with the provisions of the Council Directive 93/42/EEC concerning medical devices and fulfills the essential requirements of Annex I of this directive. The product is in radio-interference protection class A in accordance with EN 55011.

The country of manufacture can be found on the equipment labeling.

The product complies with the requirements of standard EN 60601-1-2 “Electromagnetic Compatibility - Medical Electrical Equipment”.

The safety and effectiveness of this device has been verified against previously distributed devices. Although all standards applicable to presently marketed devices may not be appropriate for prior devices (i.e. electromagnetic compatibility standards), this device will not impair the safe and effective use of those previously distributed devices. See user’s information.

General Information

- This manual is an integral part of the product and describes its intended use. It should always be kept close to the equipment. Observance of the manual is a prerequisite for proper product performance and correct operation and ensures patient and operator safety.
- The symbol ⚠ means ATTENTION: Consult accompanying documents.
- Information which refers only to certain versions of the product is accompanied by the model number(s) of the product(s) concerned. The model number is given on the nameplate of the product.
- The warranty does not cover damages resulting from the use of accessories and consumables from other manufacturers.
- GE Medical Systems *Information Technologies* is responsible for the effects on safety, reliability, and performance of the product, only if:
  - assembly operations, extensions, readjustments, modifications, or repairs are carried out by persons authorized by GE Medical Systems *Information Technologies*;
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  - the Solar 9500 Information Monitor is used in accordance with the instructions for use.
- All publications conform with the product specifications and applicable IEC publications on safety and essential performance of electromedical equipment as well as with applicable UL and CSA requirements and AHA recommendations valid at the time of printing.
- The GE Medical Systems *Information Technologies* quality management system complies with the international standards DIN EN ISO 9001 and EN 46001, and the Council Directive on Medical Devices 93/42/EEC Annex II.

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For your notes

1 The Basics

For your notes

About This Manual

Manual Purpose

This manual provides the instructions necessary to operate this device safely and in accordance with its function and intended use.

Intended Audience

This manual is geared for clinical professionals. Clinical professionals are expected to have working knowledge of medical procedures, practices, and terminology as required for monitoring of critically ill patients.

Conventions

Bold text	Indicates keys on the keyboard, text to be entered, or hardware items such as buttons or switches on the equipment.
Italicized text	Indicates software terms that identify menu items, buttons, or options in various windows.
Illustrations	All illustrations in this manual are provided as examples only. These illustrations may not represent your equipment setup or displayed data.
Names	In this manual, all names appearing in examples and illustrations are fictitious. The use of any real person's name is purely coincidental.

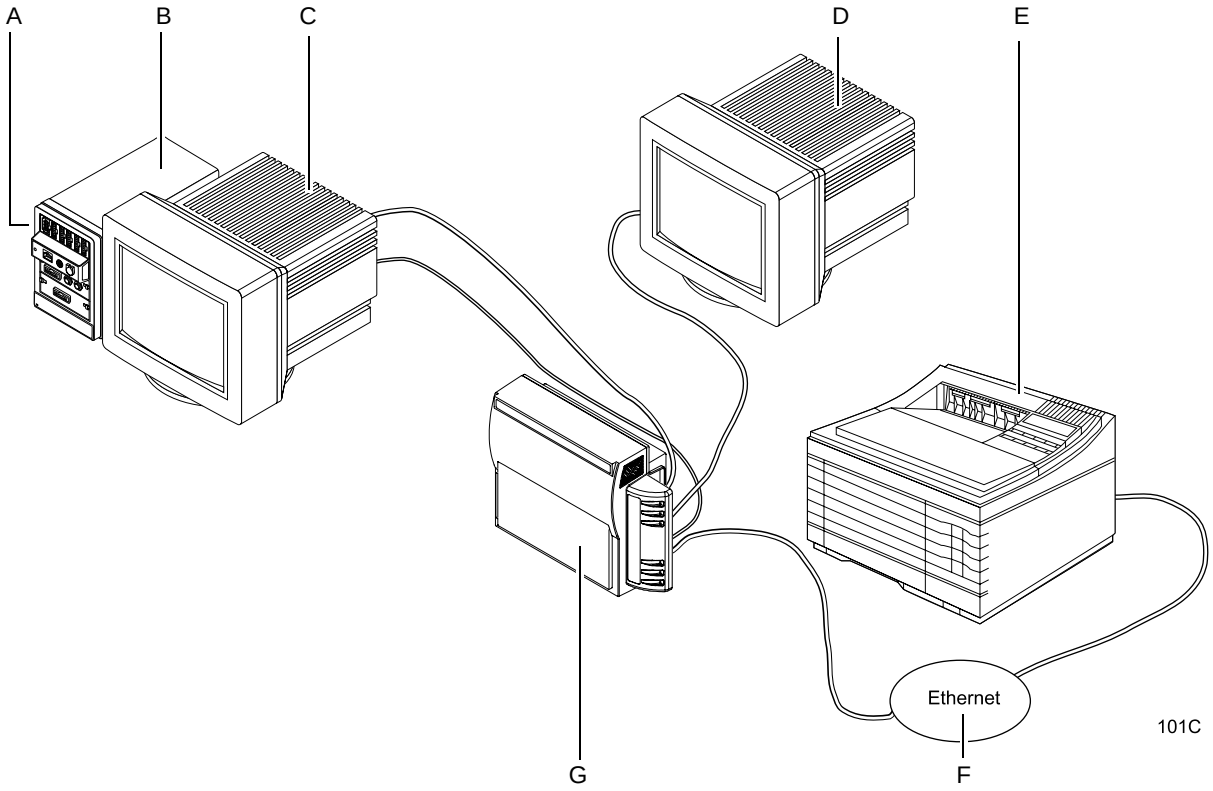
Revision History

Each page of this document has the document part number and revision letter at the bottom of the page. The revision letter changes whenever the document is updated.

Revision	Date	Comments
A	15 October 2002	Software version 3.
B	16 January 2003	Updated to include the following changes: ■ Update to the Intended Use statement, ■ New caution regarding single patient use, and ■ Note regarding viewing/printing of parameters not supported by the Solar 9500.
C	13 February 2003	Editorial correction made.

Equipment Description

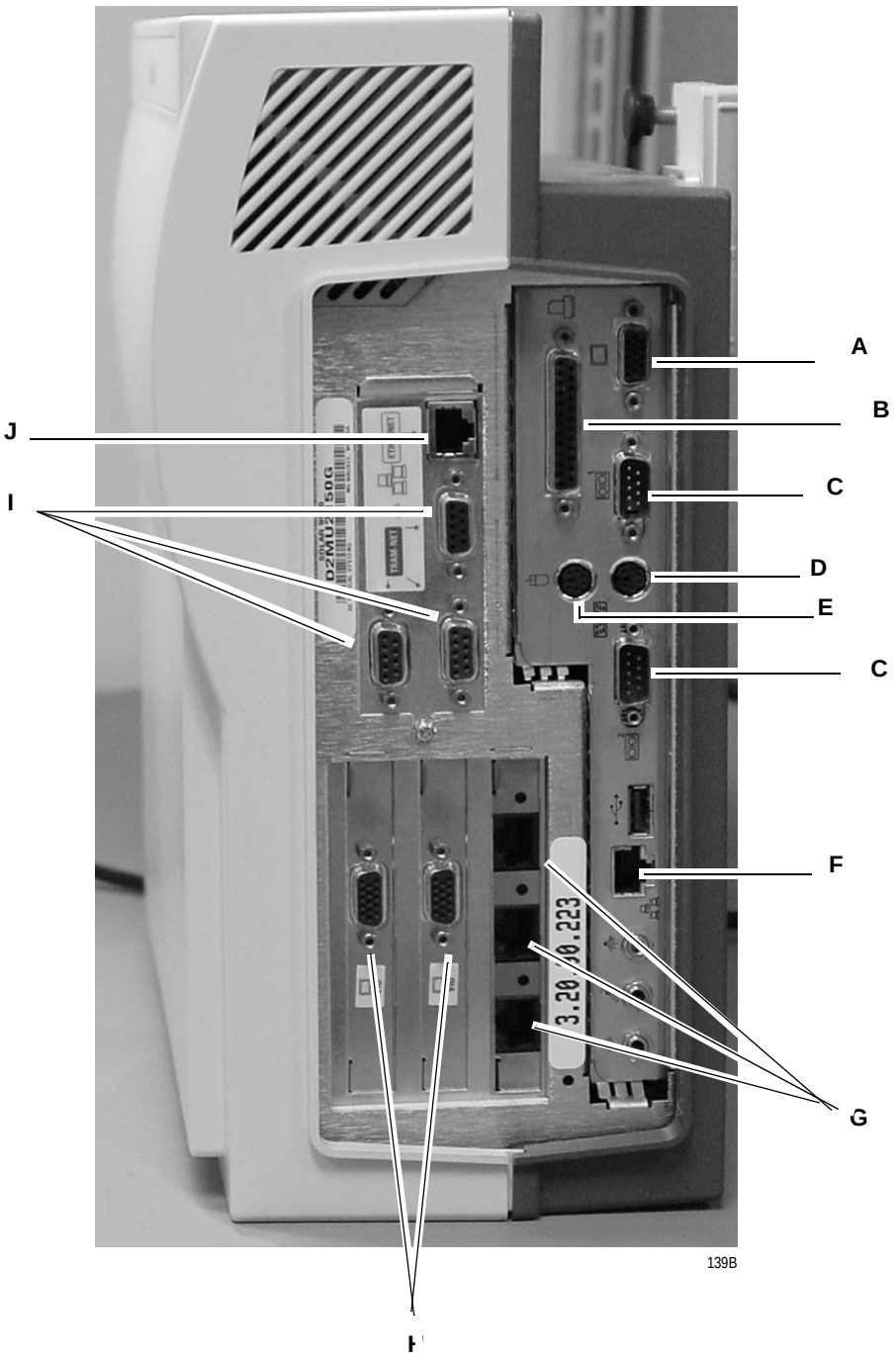
Basic System Components



Basic System Components		
	Name	**Description**
A	TRAM module	Acquires patient data.
B	TRAM-RAC housing	Holds one or more modules.
C	primary display	Displays waveform and text data.
D	remote display	Up to two remote displays can be connected. They display waveform and text data. These are purchased options.
E	postscript laser printer or PRN 50-M digital writer (not shown)	Prints the reports sent by the Solar 9500 monitor. This is a purchased option.
F	Ethernet link	Enables the Solar 9500 monitor to print patient data on the laser printer.
G	Solar 9500 processing unit	Connect to peripheral devices.

Solar 9500 Processing Unit Connectors

NOTE: The purchased multiple display option may have additional connectors.



Connector Matrix

Processing Unit Connectors		
Name		**Description**
A	display	Connect to the primary display. Supports the Browser (a user purchased option). Supports non-scrolling waveforms.
B	parallel printer	Connect to a parallel port laser printer.
C	serial	Connect to: ■ a touchscreen monitor, ■ a device requiring serial polled parameter data, ■ a PRN 50-M digital writer, ■ or a RAMS. Refer to the service manual for detailed information.
D	keyboard	Connect to a PS-2 keyboard. This is a purchased option.
E	mouse	Connect to a PS-2 mouse. This is a purchased option.
F	UNITY IX Ethernet	Non-realtime network. Connect to a laser printer or to the Browser server.
G	M-Port Connectors	Connect to: ■ Unity Network ID ■ PRN 50-M digital writer.
H	PCI graphics	Connect to a monitor display. Supports scrolling and non-scrolling waveforms.
I	TRAM-NET	Connect to a Tram-rac.
J	UNITY MC Ethernet	The UNITY real-time monitoring network.

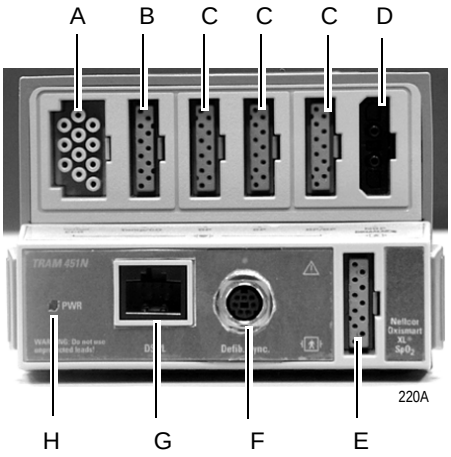
Acquisition Modules

Acquisition modules acquire physiologic patient data for display on the monitor. The Solar 9500 information monitor accepts data from Tram modules, which are multi-parameter acquisition modules. It also accepts data from the BIS®, CO2, SAM, and SvO2 single-parameter acquisition modules.

NOTE: For information about the Tram x51 series modules, refer to the Patient Monitoring System Operator's Manual Supplement for TRAM x51 Series Modules.

Tram Module Connectors

The figure below identifies the connectors for the TRAM module.

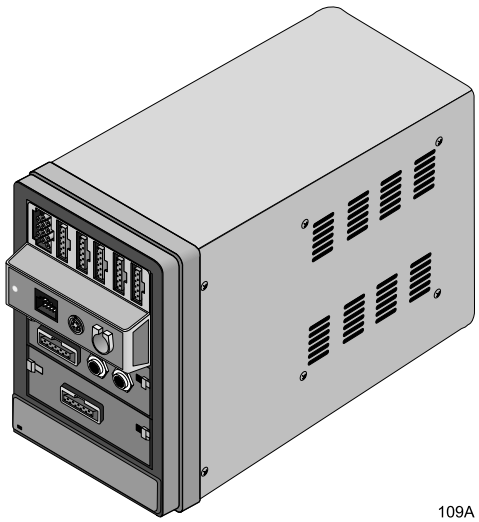


TRAM Connectors		
	Name	**Description**
A	ECG / RESP	Connect a 3-, 5-, or 10-lead ECG cable.
B	Temp / CO	Supports two temperature inputs or one cardiac output.
C	BP 1, BP 2, BP 3/4	Connect to an invasive blood pressure transducer.
D	NBP_2	Connect to a NBP cable.
E	SPO_2	Connect to a pulse oximetry probe.
F	Defib / Sync	Connect a device requiring ECG analog, BP analog, or digital synchronization output. Refer to "Appendix A – Analog Output" for more information. Refer to the Tram module service manual for the signal connector pin configuration.
G	transport display	Connect to a Smart-pac display.
H	power indicator light	Indicates the module is plugged into the Tram-rac housing.

Tram-rac Housing

The Tram-rac housing holds the Tram module and other GE Medical Systems *Information Technologies* parameter modules.

There are different models of Tram-rac housings. Tram-rac 2 houses a Tram module. Tram-rac 4A houses a Tram module plus two additional parameter modules.



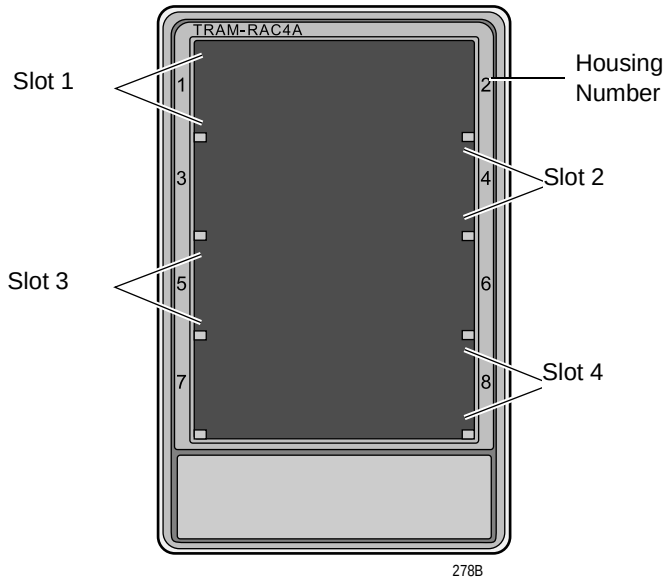
Tram-rac 4A Housing

With the exception of the Tram-rac 2 housing, each housing has an analog output connector for user-supplied equipment. Refer to this chapter, Housing Connectors, for the location of the Analog Output and Tram-net connectors. Refer to Appendices, Analog Output, for details on analog output signals, and to the Tram-rac service manual for the specific analog output signal connector pin configuration.

If you have a Tram-rac 4A housing, you can connect an additional housing to allow monitoring of additional parameters. Refer to the Tram-rac 4A service manual for details on setup.

Features of the Housing

The housing has “slots” to hold modules. Some modules are two slots high, some are only one. All Tram modules are two slots high and must be placed in the top two slots of the housing.



Tram-rac Housing Slots

The housing numbers have significance when monitoring pressures or temperatures.

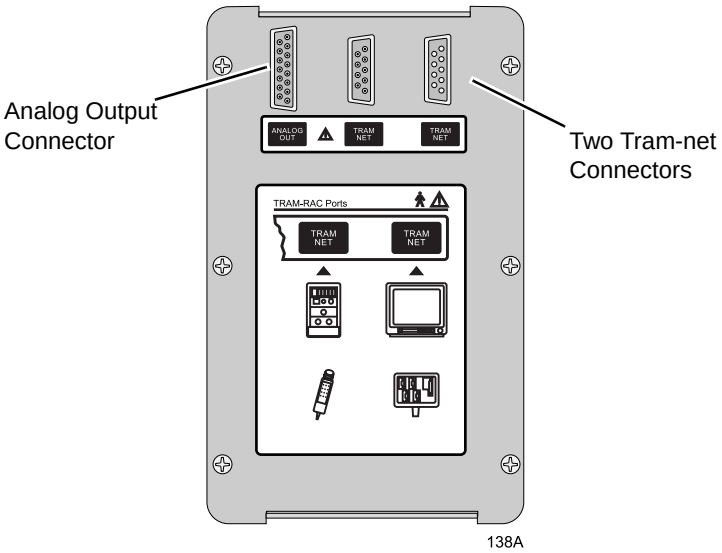
- Slots 1 and 2 are always occupied by the Tram module, which can monitor between zero and four pressures (labeled on the monitor as ART1 – ART4, as applicable).
- Slot 3 can be occupied by a dual temperature module, in which case the temperatures would be labeled on the monitor as TMP6 (numbers assigned correspond to the numbers imprinted on the Tram-rac housing at the slot edges).
- Slot 4 can also be occupied by a dual temperature module, in which case the temperatures would be labeled on the monitor as TMP8.

NOTE: Refer to “Adding Single Parameter Modules” on page 1-18 for examples of Tram-rac temperature and blood pressure module configurations.

Housing Connectors

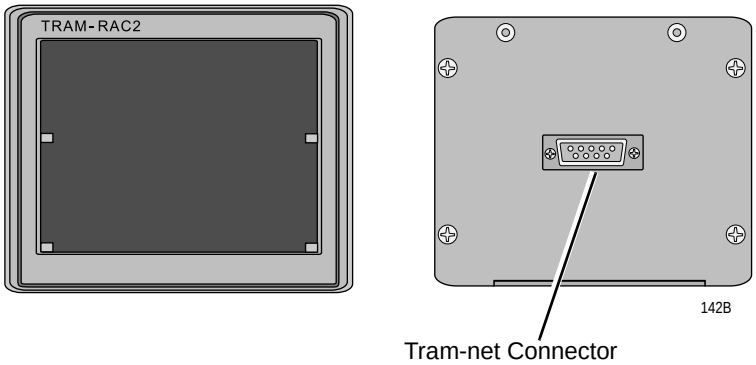
All housings have a Tram-net connector. The Tram-rac 4A housing has an Analog Output connector. The Analog Output connector supplies data from the monitor to user-supplied equipment. (Refer to Appendix A for details.) Depending on the type of Tram-rac housing you have, the connectors may be on the front panel or back panel or both.

Tram-rac 4A Connectors



Back Panel of Tram-rac 4A Housing (Without Power Supply)

Tram-rac 2 Connectors



Front and Back Panels of the Tram-rac 2 Housing

Software Description

Monitor Controls

Touchscreen

A touchscreen is a screen which has specified areas that are sensitive to touch. These areas are:

- The parameter numerics or anywhere inside the parameter window.
- The lower control buttons positioned along the bottom of the display.
- Icons, numerics, or labels in a parameter control window.
- Symbols, such as slides and directional arrows.

NOTE: Areas that are dimmed or "grayed out" are not active.

> The touchscreen feature will not function properly if tape or paper is stuck to the screen's surface. Pencils, pens, or other sharp, pointed objects should not be used to activate the touchscreen.

When you have selected a touchscreen item, the Solar 9500 Information Monitor will give you feedback with an audible tone.

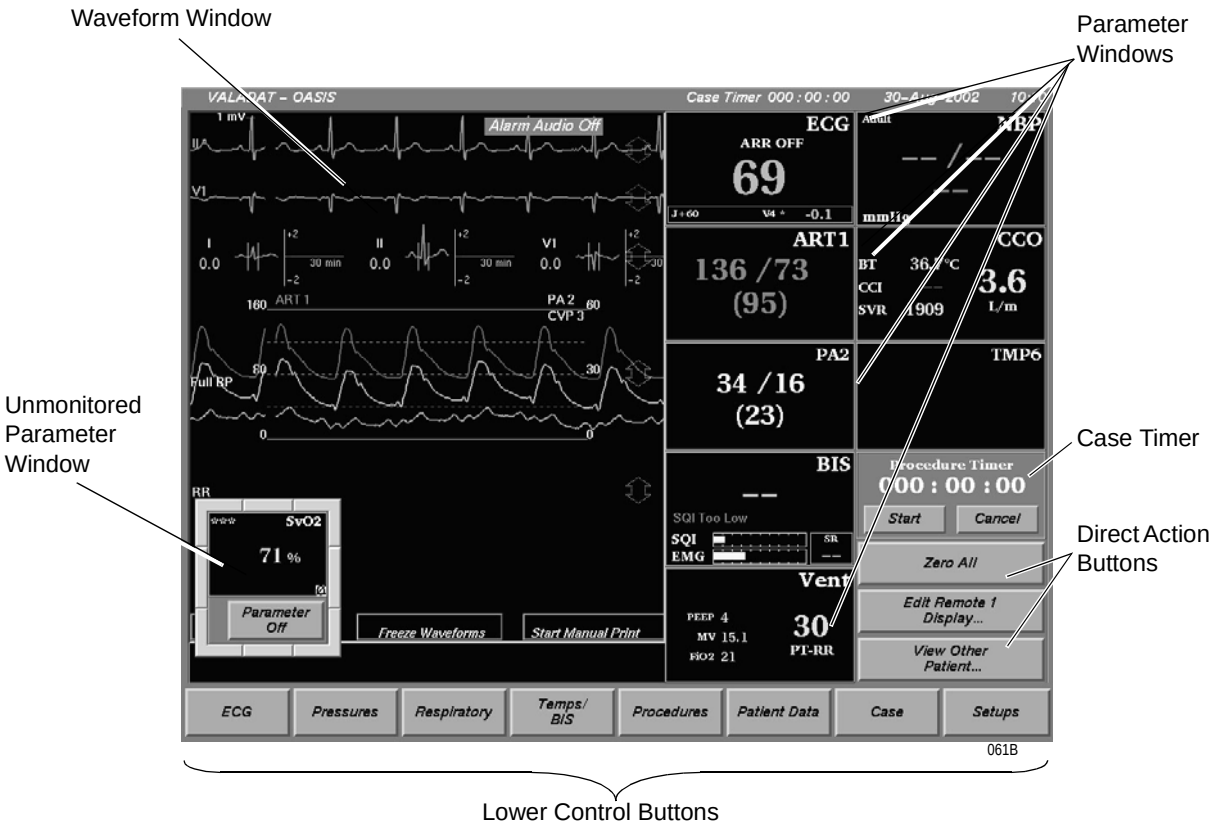
Optional Keyboard

Connect a keyboard to the appropriate connector on the side panel of the Solar 9500 Information Monitor to enter text.

Optional Mouse

Connect a mouse to the keyboard to select items without touching the screen.

Monitor Display



Lower Control Buttons

The lower control buttons allow quick access to frequently used control windows and procedure windows. These control buttons are located along the lower edge of the Solar 9500 Information Monitor display screen.

NOTE: Select *Cancel* or *Close* to either cancel or close an open popup menu.

ECG

Displays the *ECG Controls*, 12SL, Arrhythmia Review, *ST Controls*, or the ST Analysis window for active ECG parameters.

NOTE: 12SL and Arrhythmia Review are user purchased options.

Pressures

Displays the corresponding Controls window for each active monitored pressure, and provides a *ZERO ALL* option to zero all pressures.

Respiratory

Displays the active respiratory monitored RESP, Gas, CO2, SpO2, or SvO2 Controls windows.

Temps/BIS

Displays the corresponding Controls window for each active monitored temperature pair.

NOTE:
This button also allows access to the BIS menu and control window for adjusting and viewing BIS parameter data. Refer to the BIS/EEG Module Supplement for details on BIS monitoring.

Procedures

Displays *PA Wedge*, *Catheter Insertion*, *Cardiac Output*, and *12SL* (a user purchased option) procedures for active parameters.

Patient Data

Displays the *Trends*, *Cardiac Calcs*, *Alarm History*, *Arrhythmia Review* (a user purchased option), *ST Analysis*, *Patient Info*, *View Other Patient*, and *Browser* (a user purchased option) windows.

Case

- *Start Case* resets and starts the case timer. *Start Case* also allows the patient data to be accessed by a network device (i.e. MARS unity workstation or Clinical Information Center).
- *End Case* opens the *End Case* window and prevents the patient data from being accessed by a network device. *End Case* offers several options for ending the case.

  Highlight any options and select *OK* to initiate those options and end the case. If you decide not to end the case at this time, select *Close* to close the *End Case* window without making any changes.

Setups

Displays the setup of the Solar 9500 Information Monitor.

The Setups menu options are discussed in greater detail in Chapter 3, Setups Menu.

Direct Action Buttons

A direct action button turns a feature on or off, or starts a processing function.

Some of the possible direct action buttons are listed below.

NOTE: These optional buttons may or may not be present, depending on the display layout selected. For more information about creating custom layouts, refer to the service manual.

Switch Layout

Opens the *Select Layout Configuration* window.

Silence Alarms

Silences all audible alarms:

- Press once to silence an active alarm for one minute.
- Press a second time to pause alarms for five minutes.

WARNING
If an alarm condition is generated while alarms are paused, no alarm will sound, print, or broadcast on the network.

- Press a third time to reactivate alarms.

Zero All

Zeroes all monitored pressures.

NBP Go/Stop

Initiates one NBP measurement, or stops an NBP measurement in progress.

Alarm Setup…

Opens the *Alarm Setup* window.

View Other Patient…

Opens the *Patient View* window.

Browser

Opens a *Browser* window. This is a user purchased option.

Waveform Windows

All parameter information displayed on the Solar 9500 Information Monitor is gathered by the modules and RAMS unit.

Waveforms may be displayed for most of the parameters monitored by the Solar 9500 Information Monitor. The Solar 9500's primary display contains one or two columns of parameter windows. A parameter window contains the vital signs and a parameter label.

Control Windows and Procedure Windows

Control windows and procedure windows enable you to interact with the monitor. Control windows allow you to change settings for how a parameter's information is displayed. Procedure windows allow you to perform specialized functions, such as a PA wedge measurement or cardiac output trial.

Control Windows

Control windows are opened by selecting the parameter window (including unmonitored parameter windows) or via the lower control buttons.

NOTE: Only one control window may be open at a time.

Procedure Windows

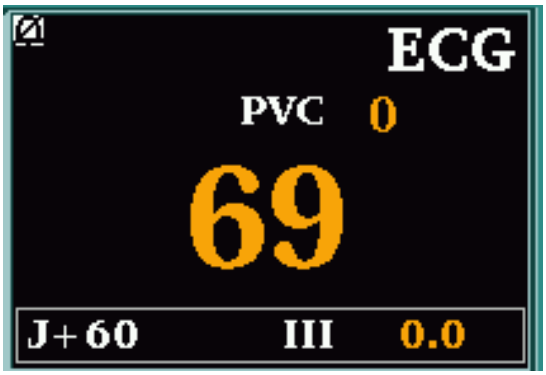
Procedure windows are opened by selecting the *Procedures* control button and choosing a procedure from the choices listed. The choices are *PA Wedge*, *Cardiac Output*, and *Catheter Insertion*.

NOTE: The choices found in the Procedures lower control popup menu change based on software options purchased, monitoring situations (e.g., the PA Wedge procedure choice is only available if PA is a currently monitored pressure), and the capabilities of the acquisition system.

Only one procedure window may be open at a time.

Parameter Windows

Each monitored parameter is labeled. Below is an example of the parameter window for ECG.



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ECG Parameter Window

Preparing the Equipment for Use

Using Two Tram-rac Housings

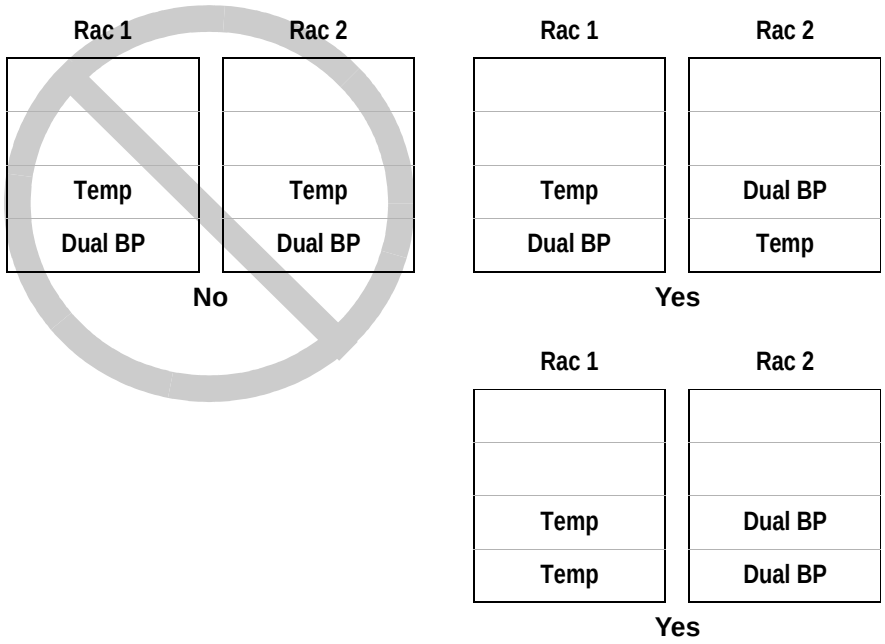
When using two housings, there are some guidelines to remember:

- One housing must have a power supply.
- One Tram module can be used.
- If the second housing is a Tram-rac 2 housing, the Tram module must go in that housing.

Adding Single Parameter Modules

When adding single parameter modules in a dual Tram-rac configuration, the following rules apply.

- One CO2 or SAM module may be used at a time.
- BP or Temperature parameter modules may not be placed in the upper two slots.
- Any BP or Temperature parameter modules may not be placed in the same slot of two different Tram-rac housings. For example:



Examples of Dual Tram-rac Configurations

Installing or Removing a Module

NOTE: The Tram module always occupies the two top "slots" in the Tram-rac housing. Other modules are installed in the remaining slots.

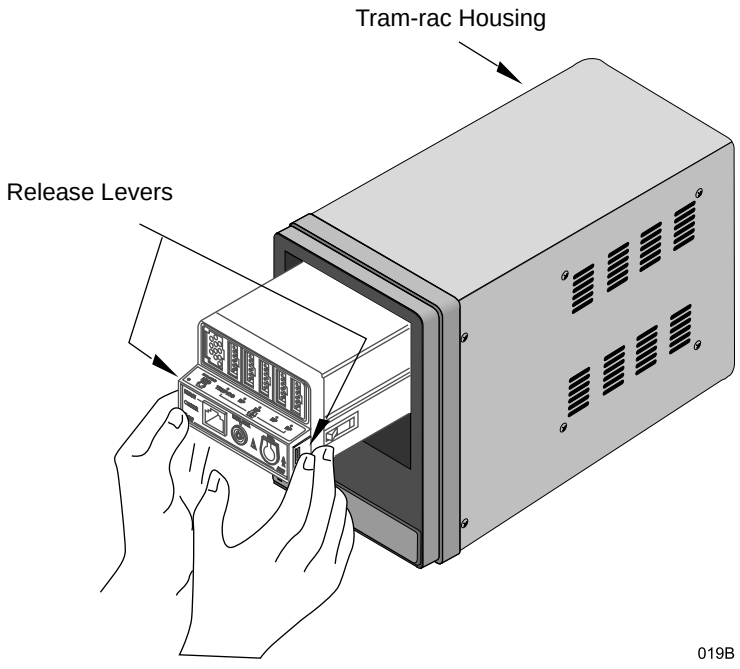
To install a module:

1. Guide the back end of the module into the appropriate slot.
2. Gently push the module into the housing. You will hear a click when the module is fully inserted.

To remove a module:

1. Press and hold the release levers* simultaneously and pull the module out about six inches.
2. Once released, grasp the module firmly with both hands and remove the rest of the way. Do not try to hold the module by the release levers.

   * The release levers for Tram modules are recessed in the side of the protruding front of the module.



Removing a Tram Module

Turning Power On

The Solar 9500 processing unit is preset at the factory for a specific AC voltage. Before applying power to the monitor, be sure its voltage setting matches your power requirements. Refer to the label on the back of the processor for the voltage and current requirements. Refer also to Power Requirements in the Safety chapter of this manual.

When all cables are properly connected and the attached display has been energized, the power switch on the back of the processor should be pressed to the “1” or ON position.

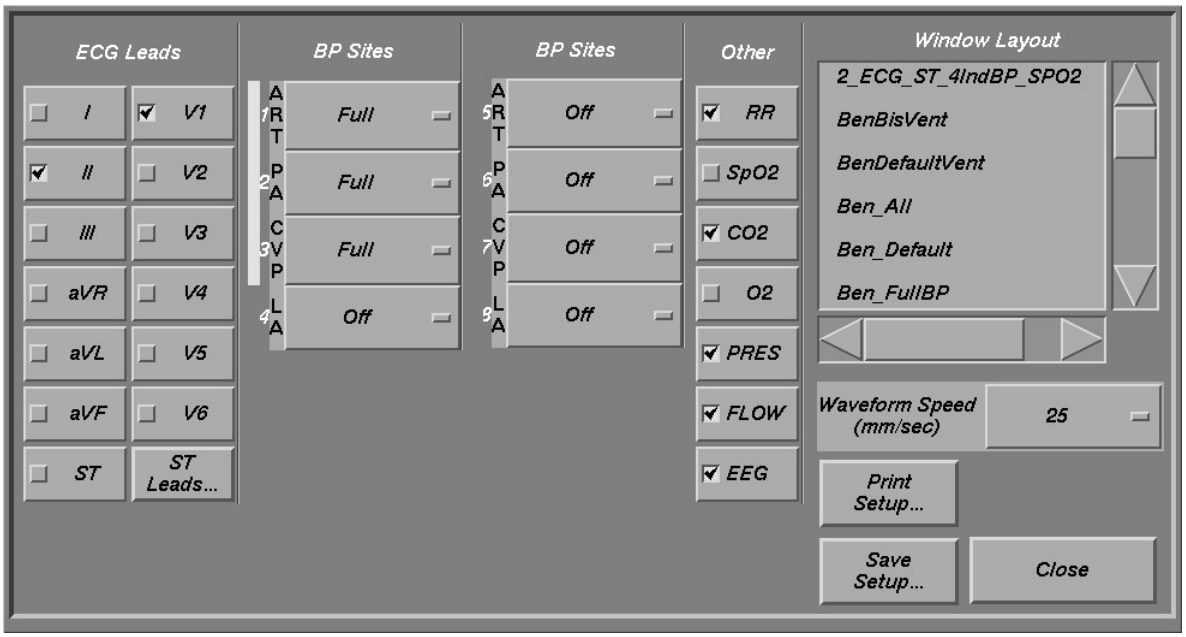
The power-up process takes approximately 2-1/2 minutes. After the power-up process is complete, all applications and printing will be active.

- Approximately 80 seconds after power-up the waveform and parameters screen is displayed and normal processing will be started.
- Several seconds after the primary display is up, the second and third displays will be functional.

NOTE: It is not necessary to switch the power off and on between cases. Power must be turned off before servicing.

Configuring Waveform Windows

Select the *Configure Window* option in the lower left corner of any waveform window to open the waveform configuration window.



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Marking a Waveform for Display

Touch or click on the parameter label to mark a waveform for display in this window. When marked for display, the light next to the parameter label illuminates.

ECG Leads—Displays the ECG leads available in the waveform configuration window. The leads vary depending on the type of cable used.

- 3-leadwire cable — Select lead I, II, or III for display.
- 5-leadwire cable — Select one or more of the following for display: I, II, III, V, aVR, aVL, aVF.
- 10-leadwire cable — Select one or more of the following for display: I, II, III, V1, V2, V3, V4, V5, V6, aVR, aVL, aVF.

ST Leads...—Enables you to select and mark the ST leads for display in the waveform window. Lead choices vary depending on the type of cable used.

BP Sites—Enables you to select different options for each BP site.

Resp—Displays waveforms for respiration rate (*RR*), *SpO2*, *CO2*, and *O2*.

Window Layout

The *Window Layout* area contains a list of saved waveform window layouts. To select one of the available options, highlight your choice.

To add a window layout to this list, refer to "Save Setup" later in this section.

Waveform Speed

The *Waveform Speed* control is a popup choice list. Waveform speed options are (in mm/second): *50*, *35*, *25*, *15*, *10*, *5*, and *1*.

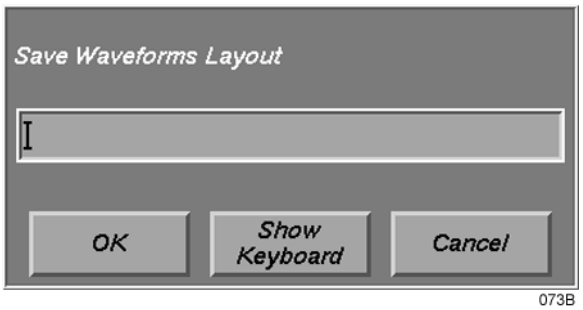
Print Setup

Refer to Chapter 5, Printing, for more information on the *Print Setup* function.

Save Setup

You can save your waveform configuration for future use.

1. Select *Save Setup*….
2. Name and save the waveforms layout.



***Save Waveforms Layout* Window**

NOTE: The Solar 9500 Information Monitor accepts alphanumeric characters, spaces, and dashes. If unacceptable characters are entered, a beep will sound.

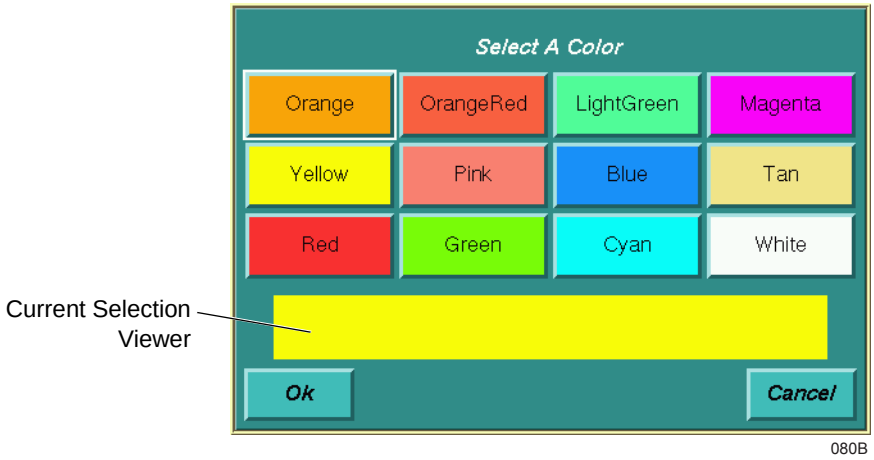
Setting the Color of Waveforms and Parameter Numerics

Most of the parameter controls windows allow you designate a color for parameter numerics and waveform display.

NOTE: There is no *Set Color*... option in the *Gas Controls* window. Each gas parameter has a fixed color corresponding to the globally accepted color for that anesthetic agent:
Desflurane = Blue
Halothane = Red
Enflurane = Amber
Isoflurane = Magenta
Sevoflurane = Yellow
N2 and N2O = White

The *Set Color*... option is also available in the parameter defaults windows, but its function is inactive unless it was accessed from within the Service menu.

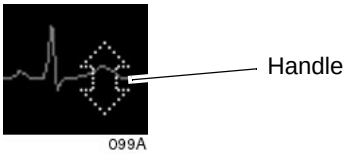
1. Select *Set Color*... in the Controls window.
2. Select the desired color option. It will be displayed in the current selection viewer.



3. Select *Ok* to activate your choice and close the window. Select *Cancel* to close the window without making changes.

Moving Waveforms

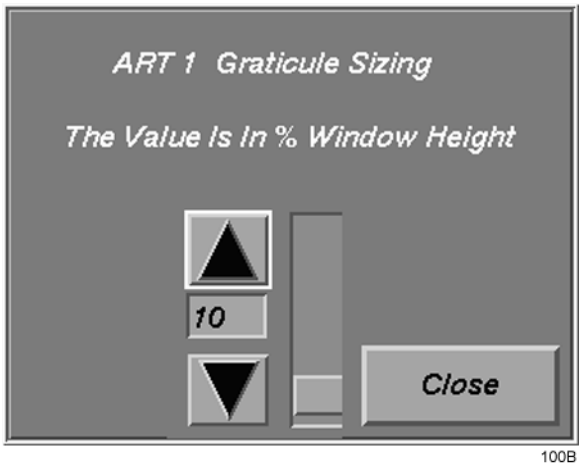
Waveforms can be moved using their handles.



Sizing Waveforms

You can select the percentage of display space given to any waveform.

1. Select the waveform label in the waveform window to open the *Graticule Sizing* window. The selected waveform's name appears in the top line of the window (*ART 1* below).
2. Use the up/down arrows or the slider control until the waveform/ graticules size suits your needs. The current value is shown in the values window.



NOTE: ECG and ST lead waveforms can only be resized from within the *ECG Controls* window.

Resp lead waveforms can only be resized from within the *Resp Controls* window.

Language-Specific Information

The following information describes differences in Solar 9500 monitor functionality when the monitor is set to certain languages (*Locale*).

French Language Information

When the Solar 9500 monitor *Locale* (language) is set to *French_France*, alarm pause duration is three minutes. Refer to "Silencing Alarms" on page 4-4.

Hungarian, Polish and Russian Language Information

Alarm broadcasts sent over the Unity network cannot be received by equipment that does not support these languages. Messages are received as a series of square boxes because the ability to display Cyrillic (Russian alphabet) and special Hungarian and Polish characters does not exist on this equipment. This is also true when a patient name, site name, or location containing Cyrillic or special Hungarian or Polish characters is sent to the MUSE system.

Japanese Language Information

When the Solar 9500 monitor Locale (language) is set to *Japanese*, the following conditions apply:

- Text for alarm broadcast over the network is in English.
- All text input is in English only (i.e., text for patient information, bed and unit names, printer names, bed and waveform layout names).

For your notes

2 Safety

For your notes

For Your Safety

Intended Use

The Solar 9500 Information Monitoring System is intended for use under the direct supervision of a licensed healthcare practitioner. The intended use of the system is to monitor physiologic parameter data on adult, pediatric and neonatal patients, in high acuity areas such as operating room (OR), post anesthesia recovery (PARR), critical care, surgical intensive care, respiratory intensive care, coronary care, medical intensive care, pediatric intensive care, or neonatal intensive care.

Physiologic data includes electrocardiogram, invasive blood pressure, noninvasive blood pressure, pulse, temperature, cardiac output, respiration, pulse oximetry, carbon dioxide, oxygen, anesthetic gas concentrations and mixed venous oxygen saturation.

The Solar 9500 Information Monitoring System is also intended to provide physiologic data over the Unity network to clinical information systems and allow the user to access hospital INTRAnet data via a Web Browser at the point-of-care. This information can be displayed, trended, stored, and printed.

Terminology

The terms danger, warning, and caution are used throughout this manual to point out hazards and to designate a degree or level of seriousness. Familiarize yourself with their definitions and significance.

Hazard is defined as a source of potential injury to a person.

DANGER indicates an imminent hazard which, if not avoided, will result in death or serious injury.

WARNING indicates a potential hazard or unsafe practice which, if not avoided, could result in death or serious injury.

CAUTION indicates a potential hazard or unsafe practice which, if not avoided, could result in minor personal injury or product/property damage.

NOTE provides application tips or other useful information to assure that you get the most from your equipment.

Monitor Safety

The safety statements presented in this chapter refer to the equipment in general and, in most cases, apply to all aspects of the monitor. There are additional safety statements in the parameter chapters which are specific to that monitored parameter.

The order in which safety statements are presented in no way implies order of importance.

Dangers

There are no dangers that refer to the equipment in general. Specific "Danger" statements may be given in the respective sections of this manual.

Warnings

WARNINGS

ACCIDENTAL SPILLS — To avoid electric shock or device malfunction liquids must not be allowed to enter the device. If liquids have entered a device, take it out of service and have it checked by a service technician before it is used again.

ACCURACY — If the accuracy of any value displayed on the monitor, central station, or printed on a graph strip is questionable, determine the patient's vital signs by alternative means. Verify that all equipment is working correctly.

ALARMS — Do not rely exclusively on the audible alarm system for patient monitoring. Adjustment of alarm volume to a low level or off during patient monitoring may result in a hazard to the patient. Remember that the most reliable method of patient monitoring combines close personal surveillance with correct operation of monitoring equipment.

After connecting the monitor to the central station, nurse-call system, and/or network, verify the function of the alarm system.

The functions of the alarm system for monitoring of the patient must be verified at regular intervals.

WARNINGS

BEFORE USE — Before putting the system into operation visually inspect all connecting cables for signs of damage. Damaged cables and connectors must be replaced immediately.

Before using the system, the operator must verify that it is in correct working order and operating condition.

Periodically, and whenever the integrity of the product is in doubt, test all functions.

CABLES — Route all cables away from patient's throat to avoid possible strangulation.

CONDUCTIVE CONNECTIONS — Extreme care must be exercised when applying medical electrical equipment. Many parts of the human/machine circuit are conductive, such as the patient, connectors, electrodes, transducers. It is very important that these conductive parts do not come into contact with other grounded, conductive parts when connected to the isolated patient input of the device. Such contact would bridge the patient's isolation and cancel the protection provided by the isolated input. In particular, there must be no contact of the neutral electrode and ground.

DEFIBRILLATION — Do not come into contact with patients during defibrillation. Otherwise serious injury or death could result.

DISCHARGE TO CLEAR PATIENT DATA — When admitting a new patient, you must clear all previous patient data from the system. To accomplish this, disconnect patient cables from the patient (if you use a Tram module be sure the module is locked in place in the Tram-rac housing) then do a discharge.

DISCONNECTION FROM MAINS — When disconnecting the system from the power line, remove the plug from the wall outlet first. Then you may disconnect the power cord from the device. If you do not observe this sequence, there is a risk of coming into contact with line voltage by inserting metal objects, such as the pins of leadwires, into the sockets of the power cord by mistake.

WARNINGS

DISPOSAL — Dispose of the packaging material, observing the applicable waste control regulations and keeping it out of children's reach.

EXPLOSION HAZARD — Do not use this equipment in the presence of flammable anesthetics, vapors or liquids.

INTERFACING OTHER EQUIPMENT — Devices may only be interconnected with each other or to parts of the system when it has been determined by qualified biomedical engineering personnel that there is no danger to the patient, the operator, or the environment as a result. In those instances where there is any element of doubt concerning the safety of connected devices, the user must contact the manufacturers concerned (or other informed experts) for proper use. In all cases, safe and proper operation should be verified with the applicable manufacturer's instructions for use, and system standards IEC 60601-1-1/EN 60601-1-1 must be complied with.

INTRACARDIAC APPLICATION — When applying devices intracardially, electrically conductive contact with parts connected to the heart (pressure transducers, metal tube connections and stopcocks, guide wires, etc.) must be avoided in all cases.

To prevent electrical contact, we recommend the following:

- always wear isolating rubber gloves,
- keep parts that are conductively connected to the heart isolated from ground,
- if possible, do not use tube fittings or stopcocks made of metal.

During intracardiac application of a device, a defibrillator and pacemaker whose proper functioning has been verified must be kept at hand.

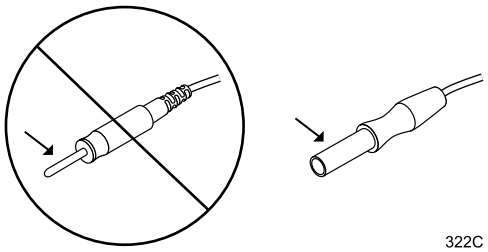
LEAKAGE CURRENT TEST — When interfacing with other equipment, a test for leakage current must be performed by qualified biomedical engineering personnel before using with patients.

WARNINGS

POWER SUPPLY — The device must be connected to a properly installed power outlet with protective earth contacts only. If the installation does not provide for a protective earth conductor, disconnect the monitor from the power line and operate it on battery power, if possible.

All devices of a system must be connected to the same power supply circuit. Devices which are not connected to the same circuit must be electrically isolated when operated (electrically isolated RS232 interface).

PROTECTED LEADWIRES — Only use protected leadwires and patient cables with this monitor. The use of unprotected leadwires and patient cables creates the potential for making an electrical connection to ground or to a high voltage power source which can cause serious injury or death to the patient.



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RATE METERS — Keep pacemaker patients under close observation. Rate meters may continue to count the pacemaker rate during cardiac arrest and some arrhythmias. Therefore, do not rely entirely on rate meter alarms.

SITE REQUIREMENTS — For safety reasons, all connectors for patient cables and sensor leads are designed to prevent inadvertent disconnection, should someone pull on them. Do not route cables in a way that they may present a stumbling hazard. For devices installed above the patient, adequate precautions must be taken to prevent them from dropping on the patient.

Cautions

CAUTIONS

ACCESSORIES (SUPPLIES) — To ensure patient safety, use only parts and accessories manufactured or recommended by GE Medical Systems *Information Technologies*.

Parts and accessories used must meet the requirements of the applicable IEC 60601 series safety standards and essential performance standards, and/or the system configuration must meet the requirements of the IEC 60601-1-1 medical electrical systems standard.

ACCESSORIES (EQUIPMENT) — The use of ACCESSORY equipment not complying with the equivalent safety requirements of this equipment may lead to a reduced level of safety of the resulting system. Consideration relating to the choice shall include:

- use of the accessory in the PATIENT VICINITY; and
- evidence that the safety certification of the ACCESSORY has been performed in accordance to the appropriate IEC 60601-1 and/or IEC 60601-1-1 harmonized national standard.

BATTERY POWER — If a device equipped with an optional battery pack will not be used or not be connected to the power line for a period of over six months, remove the battery.

BEFORE INSTALLATION — Compatibility is critical to safe and effective use of this device. Please contact your local sales or service representative prior to installation to verify equipment compatibility.

DEFIBRILLATOR PRECAUTIONS — Patient signal inputs labeled with the CF and BF symbols with paddles are protected against damage resulting from defibrillation voltages. To ensure proper defibrillator protection, use only the recommended cables and leadwires.

Proper placement of defibrillator paddles in relation to the electrodes is required to ensure successful defibrillation.

CAUTIONS

DISPOSABLES — Disposable devices are intended for single use only. They should not be reused as performance could degrade or contamination could occur.

DISPOSAL — At the end of its service life, the product described in this manual, as well as its accessories, must be disposed of in compliance with the guidelines regulating the disposal of such products. If you have questions concerning disposal of the product, please contact GE Medical Systems *Information Technologies* or its representatives.

ELECTROCAUTERY PRECAUTIONS — To prevent unwanted skin burns, apply electrocautery electrodes as far as possible from all other electrodes, a distance of at least 15 cm/6 in. is recommended.

EMC — Magnetic and electrical fields are capable of interfering with the proper performance of the device. For this reason make sure that all external devices operated in the vicinity of the monitor comply with the relevant EMC requirements. X-ray equipment or MRI devices are a possible source of interference as they may emit higher levels of electromagnetic radiation.

INSTRUCTIONS FOR USE — For continued safe use of this equipment, it is necessary that the listed instructions are followed. However, instructions listed in this manual in no way supersede established medical practices concerning patient care.

LOSS OF DATA — Should the monitor at any time temporarily lose patient data, the potential exists that active monitoring is not being done. Close patient observation or alternate monitoring devices should be used until monitor function is restored.

If the monitor does not automatically resume operation within 60 seconds and no messages or data are present on the display, power cycle the monitor using the power on/off switch. Once monitoring is restored, you should verify correct monitoring state and alarm function.

MAINTENANCE — Regular preventive maintenance should be carried out annually. You are responsible for any requirements specific to your country.

CAUTIONS

MPSO — The use of a multiple portable socket outlet (MPSO) for a system will result in an enclosure leakage current equal to the sum of all individual earth leakage currents of the system if there is an interruption of the MPSO protective earth conductor. Do not use an additional extension cable with the MPSO as it will increase the chance of the single protective earth conductor interruption.

NEGLIGENCE — GE Medical Systems *Information Technologies* does not assume responsibility for damage to the equipment caused by improperly vented cabinets, improper or faulty power, or insufficient wall strength to support equipment mounted on such walls.

OPERATOR — Medical technical equipment such as this monitor/monitoring system must only be used by persons who have received adequate training in the use of such equipment and who are capable of applying it properly.

POWER REQUIREMENTS — Before connecting the device to the power line, check that the voltage and frequency ratings of the power line are the same as those indicated on the unit's label. If this is not the case, do not connect the system to the power line until you adjust the unit to match the power source.

In U.S.A., if the installation of this equipment will use 240V rather than 120V, the source must be a center-tapped, 240V, single-phase circuit.

RESTRICTED SALE — U.S. federal law restricts this device to sale by or on the order of a physician.

SECURITY — The browser that runs in conjunction with the Solar 9500 information monitor is intended for hospital INTRANET use only. If confidential patient information is made available from the hospital intranet, the security of the data is the responsibility of the hospital.

CAUTIONS

SINGLE PATIENT USE — This equipment is designed for use on one patient at a time. Using this equipment to monitor different parameters on different patients at the same time compromises the accuracy of data acquired.

SUPERVISED USE — This equipment is intended for use under the direct supervision of a licensed health care practitioner.

VENTILATION REQUIREMENTS — Set up the device in a location which affords sufficient ventilation. The ventilation openings of the device must not be obstructed. The ambient conditions specified in the technical specifications must be ensured at all times.

Notes

- Choose a location which affords an unobstructed view of the monitor's screen and easy access to the operating controls.
- This product is not likely to cause abnormal operation of other patient-connected equipment such as cardiac pacemaker or other electrical stimulators. Exceptions are noted in the pacemaker monitoring section, if applicable.
- This product is protected against the effects of cardiac defibrillator discharges to ensure proper recovery, as required by test standards. (The screen may blank during a defibrillator discharge but recovers within seconds as required by test standards.)

Reference Literature

Medical Device Directive 93/42/EEC

EN 60601-1/1990 + A1: 1993 + A2: 1995: Medical electrical equipment. General requirements for safety

EN 60601-1-1/9.1994 + A1 12.95: General requirements for safety. Requirements for the safety of medical electrical systems.

IEC Publication 513/1994: Fundamental aspects of safety standards for medical equipment.

ROY, O.Z.: Summary of cardiac fibrillation thresholds for 60-Hz currents and voltages applied directly to the heart. Med. & Biol. Engn. & Computing 18: 657...659 (1980).

Classifications

Equipment components are classified, according to IEC 60601-1, as:

	Type of protection against electrical shock	Degree of protection against electrical shock	Degree of protection against harmful ingress of water	Degree of safety of application in the presence of a flammable anesthetic mixture with air or with oxygen or nitrous oxide	Method(s) of sterilization or disinfection recommended by the manufacturer	Mode of operation
Solar 9500 CPU	I	Not Marked	Ordinary	Not Suitable	NA	Continuous
Tram modules:						
ECG, BP, Temp, CO	NA	CF	Ordinary	Not Suitable	NA	Continuous
NBP, SPO2	NA	BF	Ordinary	Not Suitable	NA	Continuous
Dual BP module	NA	CF	Ordinary	Not Suitable	NA	Continuous
BP/Dual temp module	NA	CF	Ordinary	Not Suitable	NA	Continuous
Dual temp module	NA	CF	Ordinary	Not Suitable	NA	Continuous
SvO2 module	NA	B	Ordinary	Not Suitable	NA	Continuous
CO2 modules	NA	BF	Ordinary	Not Suitable	NA	Continuous
SAM module	NA	B	Ordinary	Not Suitable	NA	Continuous
RAMS unit	I	B	Ordinary	Not Suitable	NA	Continuous
Tram-net interface adapter	NA	Not Marked	Ordinary	Not Suitable	NA	Continuous
Tram-rac without power supply	NA	Not Marked	Ordinary	Not Suitable	NA	Continuous
Tram-rac with power supply	I	Not Marked	Ordinary	Not Suitable	NA	Continuous
PRN 50-M writer	I	Not Marked	Ordinary	Not Suitable	NA	Continuous

KEY I: Class I equipment
B: Type B applied part
BF: Type BF applied part
CF: Type CF applied part
NA: Not applicable
Ordinary: Ordinary equipment (enclosed equipment without protection against ingress of water)
Not Suitable: Equipment not suitable for use in the presence of a flammable anesthetic mixture with air or with oxygen or nitrous oxide

Underwriters Laboratories, Inc.

4P41

Medical Equipment
With respect to electric shock, fire and mechanical hazards only in accordance with UL 2601-1, and CAN/CSA C22.2 NO. 601.1.

Equipment Symbols

NOTE: Some symbols may not appear on all equipment.

ATTENTION: Consult accompanying documents.

CAUTION: To reduce the risk of electric shock, do NOT remove cover. Refer servicing to qualified service personnel.

TYPE CF APPLIED PART: Isolated (floating) applied part suitable for intentional external and internal application to the patient including direct cardiac application. “Paddles” outside the box indicate the applied part is defibrillator proof.

[Medical Standard Definition:] F-type applied part (floating/isolated) complying with the specified requirements of IEC 60601-1/UL 2601-1/CSA 601.1 Medical Standards to provide a higher degree of protection against electric shock than that provided by type BF applied parts.

NOTE: The rating of protection against electric shock (indicated by symbol for CF or BF) is achieved only when used with patient applied parts recommended by GE Medical Systems *Information Technologies*.

TYPE BF APPLIED PART: Isolated (floating) applied part suitable for intentional external and internal application to the patient excluding direct cardiac application. “Paddles” outside the box indicate the applied part is defibrillator proof.

[Medical Standard Definition:] F-type applied part (floating/isolated) complying with the specified requirements of IEC 60601-1/UL 2601-1/CSA 601.1 Medical Standards to provide a higher degree of protection against electric shock than that provided by type B applied parts.

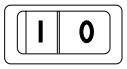
TYPE B APPLIED PART: Non-isolated applied part suitable for intentional external and internal application to the patient excluding direct cardiac application.

[Medical Standard Definition:] Applied part complying with the specified requirements of IEC 60601-1/UL 2601-1/CSA 601.1 Medical Standards to provide protection against electric shock, particularly regarding allowable leakage current.

Fuse

Equipotential

Alternating current (AC)



Power; 1 = ON; 0 = OFF

Indicates where to press to open the door on the 7160 DDW.

For your notes

3 Setups Menu

For your notes

Introduction

Screen configurations can be designed and saved for easy retrieval. The tools for doing this are located in the Setups menu.

To open the Setups popup menu, select the *Setups* lower control button.

NOTE: There are additional menu options available when layout configuration is enabled (indicated with *).

The choices are:

Cancel

Switch Layout...

Edit Remote 1 Display...**

Edit Remote 2 Display...**

Alarm Setup...

Alarm Graph Setup...

Parameters On/Off...

Select Printers...

Save Layout*

Turn Layout Configuration Off *

Configuration/Service...

* Because layout configuration is a function of the service mode, it is not discussed in this manual. For more information on layout configuration, refer to the service manual.

** This option is available only if the system is configured with a remote display.

Cancel

To close the window without making changes, select *Cancel*.

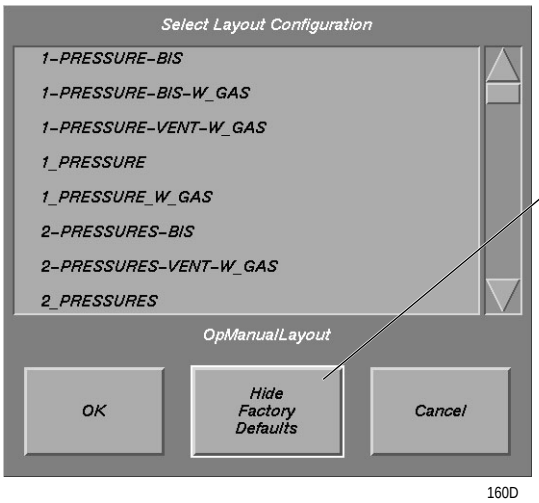
NOTE: This option controls the selected layout for the primary display only. To change the layout selection for the remote display select *Edit Remote Display…* from the Setups popup menu. Refer to the "Edit Remote Display…" section in this chapter for more information.

For information on creating layout configurations, refer to the service manual.

WARNING
Do not configure the screen in such a way that parameter data and alarm information is obscured. This could delay recognition of critical events.

Switch Layout

Select *Switch Layout*... to open the *Select Layout Configuration* window.



***Select Layout Configuration* Window**

Switching a Layout

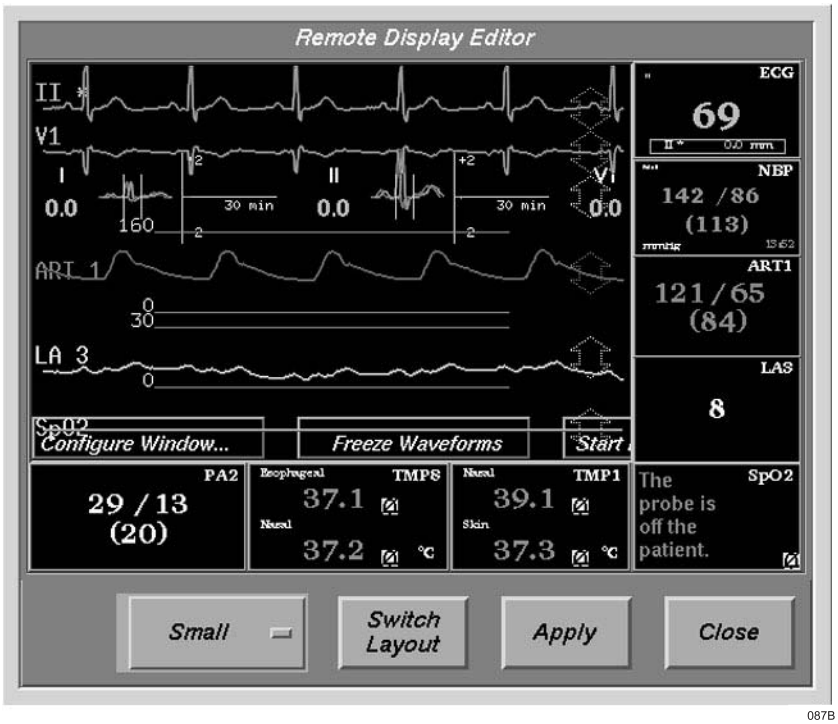
To switch the layout for the primary display, highlight a saved layout from the list of available options and select *OK*.

Show/Hide Factory Defaults

Selecting *Show Factory Defaults* displays the factory default layouts. Correspondingly, selecting *Hide Factory Defaults* removes them from the list of available layouts.

Edit Remote Display

The *Edit Remote Display...* option opens the *Remote Display Editor* window.



***Remote Display Editor* Window**

A scaled-down version of the Remote Display opens, including editing controls. All of the Remote Display controls are active in the *Remote Display Editor*.

Editing Controls

The editing controls are listed below.

Editor Size

The left-hand button lets you resize the *Remote Display Editor* window. Choices are *Small*, *Medium*, and *Large*. The current size selection is indicated on the button itself.

Switch Layout

Opens the *Select Layout Configuration* window, including a list of available layouts.

NOTE: This control only affects the Remote Display Editor window.

Apply

Applies any changes you have made in the *Remote Display Editor* window to the remote display.

NOTE: You must select *Apply* to implement any changes you have made to the *Remote Display Editor* window or all changes will be lost when the window is closed.

Close

Closes the *Remote Display Editor* window.

Waveform Window Controls

The *Configure Window…*, *Freeze Waveforms*, and *Start Manual Print* controls are functional in the Remote display.

Selecting *Configure Window…* opens the *Configure Waveform* window, where you can mark parameters to display waveforms, select a waveform window layout, set waveform speed, configure print setup, and save setup. For more information on configuring waveform windows, refer to "Configuring Waveform Windows" in Chapter 1, The Basics.

Selecting *Freeze Waveforms* on the display editor will stop waveform scrolling in the waveform window. Once it is selected, the option label changes to *Continue*. Select *Continue* to resume waveform scrolling.

NOTE: Waveforms unfreeze when any alarm occurs, or if a waveform is moved or resized, to allow a view of real-time information.

Selecting *Start Manual Print* prints waveforms to the printer selected for manual printing. Refer to Chapter 5, Printing, for more information.

Alarm Setup

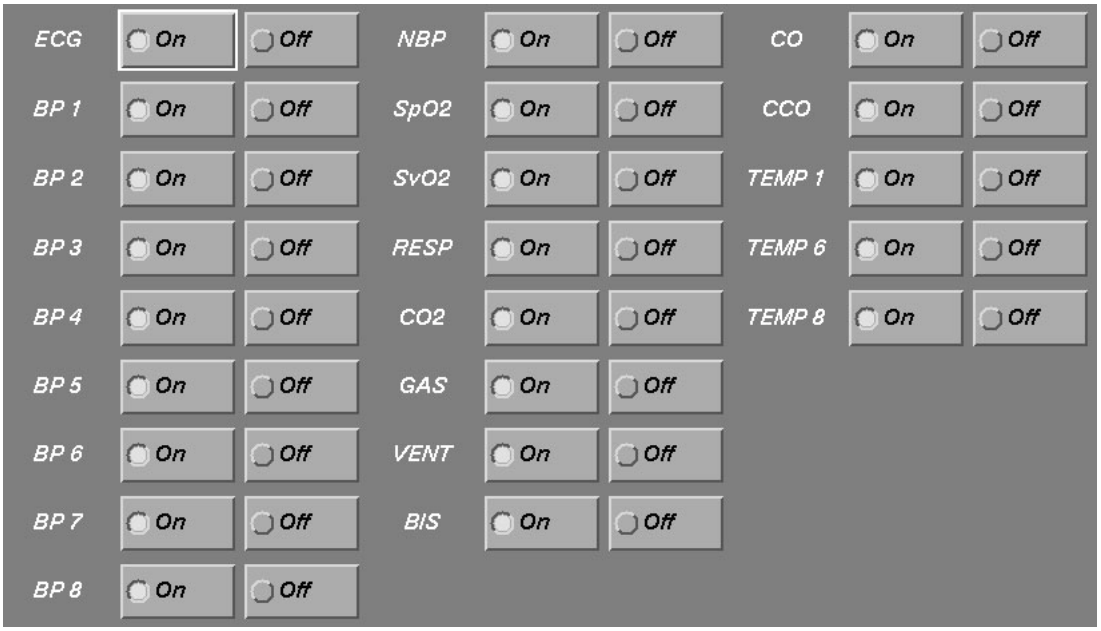
Refer to Chapter 4, Alarms.

Alarm Graph Setup

Refer to Chapter 5, Printing.

Parameters On/Off

The *Parameters On/Off*... option opens a window which shows all parameters supported by the Solar 9500 monitor.



***Parameters On/Off* Window**

Each of the parameter labels has *On* and *Off* buttons next to it. To turn a parameter on or off, select *On* or *Off* next to the corresponding label. After selected, a indicator light is lit next to the chosen button label.

Turning a parameter off will stop all processing of that parameter. No waveforms, numerics, alarms, or trends are provided for parameters that are turned off.

NOTE: Turning a parameter off does not remove a parameter block from a layout.

CAUTION
If you disconnect a parameter cable at any point along the cable or disconnect it from the module, and the parameter window is removed from the monitor display, all alarm limits may revert to the set monitor default alarm limits when the cable is reconnected.

Unmonitored Parameters

If a parameter that is not accommodated by the currently selected layout is turned on in the *Parameters On/Off* Window, an "*Unmonitored Parameter*" window will appear on the left side of the primary display. This window can be resized and repositioned on the display by touching and dragging on the unmonitored parameter window's border.

***NBP* Unmonitored Parameter Window**

IMPORTANT

When *Parameter Off* is selected, the unmonitored parameter will be removed from the display. The parameter remains turned off until it is manually turned back on from within the *Parameters On/Off* window.

When a new layout that accommodates a previously unmonitored parameter is selected, the parameter will remain off. However, the parameter window will be displayed. A message in the parameter window will indicate that it is turned off. Touch the parameter window to turn the parameter on.

NOTE: Touching the parameter window to turn the parameter on will not occur if there are not enough waveforms selected. Refer to "Configuring Waveform Windows" on page 1-21 for details on configuring waveform.

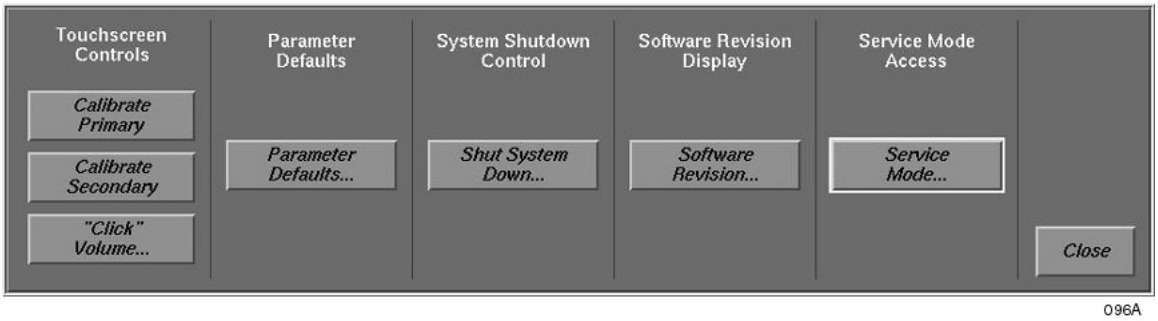
If a parameter that IS accommodated by the currently selected layout is turned off, a message in the parameter window will indicate that it is turned off.

Select Printers

Refer to Chapter 5, Printing.

Configuration/Service

Selecting the *Configuration / Service...* option opens the user configuration window.



User Configuration Window

Touchscreen Controls

The touchscreen controls options are *Calibrate Primary*, *Calibrate Secondary*, and *"Click" volume...*.

Calibrate

When *Calibrate Primary* is selected, the touchscreen alignment procedure is initiated for the primary display. If a touchscreen is active on a secondary display, selecting *Calibrate Secondary* will initiate the touchscreen alignment procedure for that display.

When the alignment procedure is initiated, the monitor screen turns black, and a pressure-sensitive target icon and "*Please Touch & Hold*" prompt appears in the upper left corner of the screen.

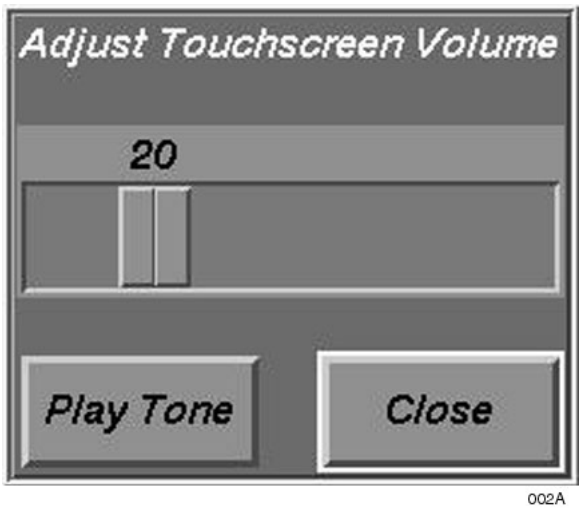
Press your finger as closely to the center of the target icon as possible. Hold your finger in place until the target icon changes color, and the "*Please Release*" prompt appears, at which time you may stop touching the screen.

Following the prompts, repeat this process in the other three corners of the screen. When the alignment procedure is complete, the *User Configuration* window is displayed again.

NOTE: If the touchscreen is not configured, or is not working, the calibration procedure will time out, and the previous calibration data will be used.

Click Volume

When *"Click" volume...* is selected, the *Adjust Touchscreen Volume* window opens.



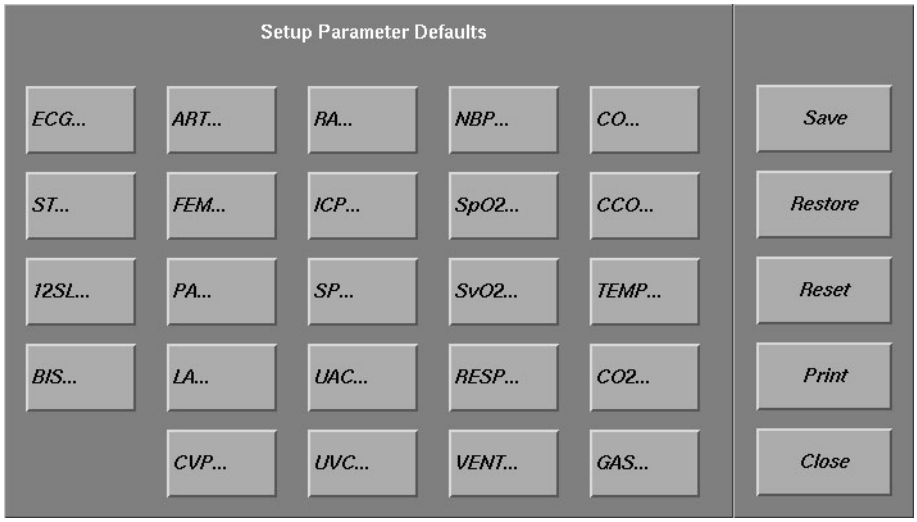
Adjust Touchscreen Volume Window

Use the slide control to set the touchscreen volume at the desired level. As the level is adjusted, "clicks" sound at the new level. Select *Play Tone* to sound an audible tone at the current volume level.

NOTE: The touchscreen volume resets to its factory default value whenever the monitor is reset or powered down.

Parameter Defaults

The *Parameter Defaults* option opens the *Setup Parameter Defaults* window.



***Setup Parameter Defaults* Window**

The *Setup Parameter Defaults* window can be accessed via the *User Configuration / Service* menu, or from the *Service Mode Access* menu. Modifications to the parameter defaults can only be made system defaults if the window was accessed via the Unit Defaults selection within the Service menu. When this window is opened from the user mode (i.e., not accessed from within service mode), the only options available are *Restore*, *Print*, and *Close*.

Restore—Selecting the *Restore* option will return all settings back to the most recently saved settings. When *Restore* is selected, a message window opens:

> *"This will change all parameter settings back to the user defaults. Do you wish to continue?"*

Select *Yes* to change the settings, or *No* to close the message window without making changes.

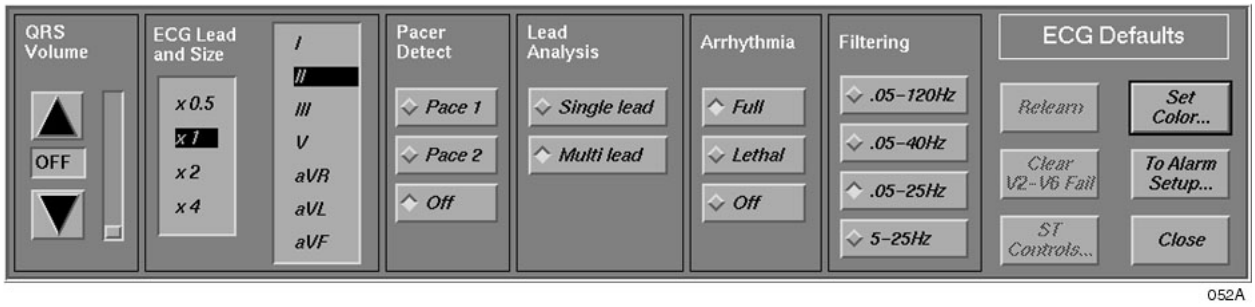
Print—Selecting *Print* will initiate a printout of the saved user default settings for all of the available parameters.

It is recommended that you print default settings once you have finished making changes.

Close—Selecting *Close* will close the *Setup Parameter Defaults* window.

Individual Parameter Default Windows

To modify the default settings for an available parameter, select the appropriate labeled button from the *Setup Parameter Defaults* window. An example is shown below. Information in each parameter default window will vary.



ECG Defaults Window

A parameter's alarm default settings are modified and saved by accessing the *Alarm Setup* window from the parameter's default window. For more information on alarm setup, refer to Chapter 4, Alarms and Limits.

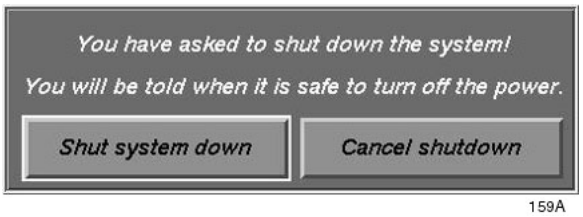
After making modifications to an individual parameter's default window, close that window. The system returns to the *Setup Parameter Defaults* window. Select *Save* to save your modifications, and then select *Restore* to apply your modifications.

CO2 Parameter Default Window

Because CO2 data can be acquired from modules with different capabilities, the parameter defaults change. To get the correct defaults, be sure to save modifications with the appropriate CO2 module inserted (i.e., the one you intend to work with).

System Shutdown

To power down the processing unit, select *Configuration / Service* from the Setups lower control button. The User Configuration window opens, where you can select *Shut System Down...* A confirmation screen (displayed below) will display.


You have asked to shut down the system!
You will be told when it is safe to turn off the power.
Shut system down
Cancel shutdown
159A

Select "*Shut system down*" to begin the orderly shut down process. Wait until the message "*Caution: Do not move the Solar 9500 monitor for 40 seconds after turning power off.*" appears and complete shut down by pressing the **O** on the on/off power switch on the back of the processing unit.

CAUTIONS

- Do not move the system while turning power off. Wait 40 seconds after removing power before moving the system.
- All monitoring will be suspended for approximately 3 minutes after system is shut down.

Software Revision

To view a window displaying information regarding current software revisions (versions) in use on your system, select *Configure / Service...* from the Setups popup menu. The User Configuration window opens. Select *Software Revision...* to open the *Revision Information* window.

Select *Print* to print the contents of the *Revision Information* window, or *Close* to close it.

NOTE: Be sure that the software versions you are using are at the required levels displayed in this window or higher.

Service Mode

The *Service* mode is meant for qualified field engineers, factory service personnel, and hospital biomedical engineers to set up, troubleshoot, and repair the monitor. Refer to the service manual for more details.

For your notes

4 Alarms

For your notes

Alarm Structure

The alarm structure of the monitor is divided into two classifications:

- Patient Status Alarms, and
- System Status Alarms.

Within each classification there are levels which correlate to the severity of the condition causing the alarm. The levels and how the monitor responds to each are described below. Patient status alarms can, in most cases, be moved from one level to another.

Patient Status Alarms

Patient status alarms are triggered by a patient condition which exceeds parameter limits, or by an arrhythmia condition. Patient status alarms provide the highest priority information.

The levels within the Patient Status Alarm category and how the monitor responds to each is shown in the following table. The table begins with the most critical type of alarm (Crisis) and ends with the least critical type of alarm (Message).

Patient Status Alarms						
Alarm	**Audio**	**Visual**	**Automatic Printout[2]**	**Alarms Stored in Alarm History**	**Arrhythmias Stored in Arrhythmia Review**	**Network Broadcast**
CRISIS[1]	3 repeating beeps	red background	yes	yes	yes	yes
WARNING	2 repeating beeps	yellow background	yes	yes	yes	yes
ADVISORY	1 repeating beep	amber background	no	yes	yes	yes
MESSAGE[3]	none	blue background	no	yes	no	no

[1] Crisis alarms sound until silenced by the user. Warning and Advisory alarms sound until the condition is resolved.

[2] Automatic alarm printouts occur only when turned on in *Alarm Setup*.

[3] Message alarms do not sound. They have a blue background on the display until the condition is resolved.

System Status Alarms

System status alarms are triggered by mechanical or electrical problems and are of lesser priority than patient status alarms. The levels within the System Status Alarm category and how the monitor responds to each are shown in the following chart.

NOTE: All System Status Alarms will silence automatically when the the condition is resolved.

System Status Alarms				
Alarm	**Audio**	**Visual**	**Alarms Stored in Alarm History**	**Network Broadcast**
WARNING	repeating foghorn	red text	yes	yes
ADVISORY	single foghorn	red text	yes	no
MESSAGE	none	red or grey text	yes	no

Silencing Alarms

The top waveform window will signify the audible alarm condition by displaying an "*Alarms Silenced*" or "*Alarms Paused*" message.

WARNING
If an alarm condition is generated during *Alarms Paused*, no alarm will sound, print, or be broadcasted on the network.

To silence an alarm condition, a *Silence Alarms* direct action button must be present on the layout being used.

- When *Silence Alarms* is selected once, the active alarm is silenced for one minute. If any other alarm condition is generated at an equal or higher alarm level, the alarm will sound at the new alarm's level.
- When *Silence Alarms* is selected twice, the active alarm is silenced for five minutes. This is called "*Alarms Paused*".

  NOTE: When the Solar 9500 monitor Locale (language) is set to *French_France*, alarm pause is three minutes.

- When *Silence Alarms* is selected three times, all alarms are reactivated.
- When *Silence Alarms* is selected and no alarm condition is present, the monitor will go directly into the *Alarms Paused* state as described above.

Patient Status Alarms

Each alarm level elicits a specific response from the monitor. The four alarm levels are configurable. This means that an alarm can be moved from one category to another if the default is not satisfactory to your situation.

Alarm Setup Window

Alarm levels are set up and modified in the *Alarm Setup* window. Limits are also defined within the *Alarm Setup* window.

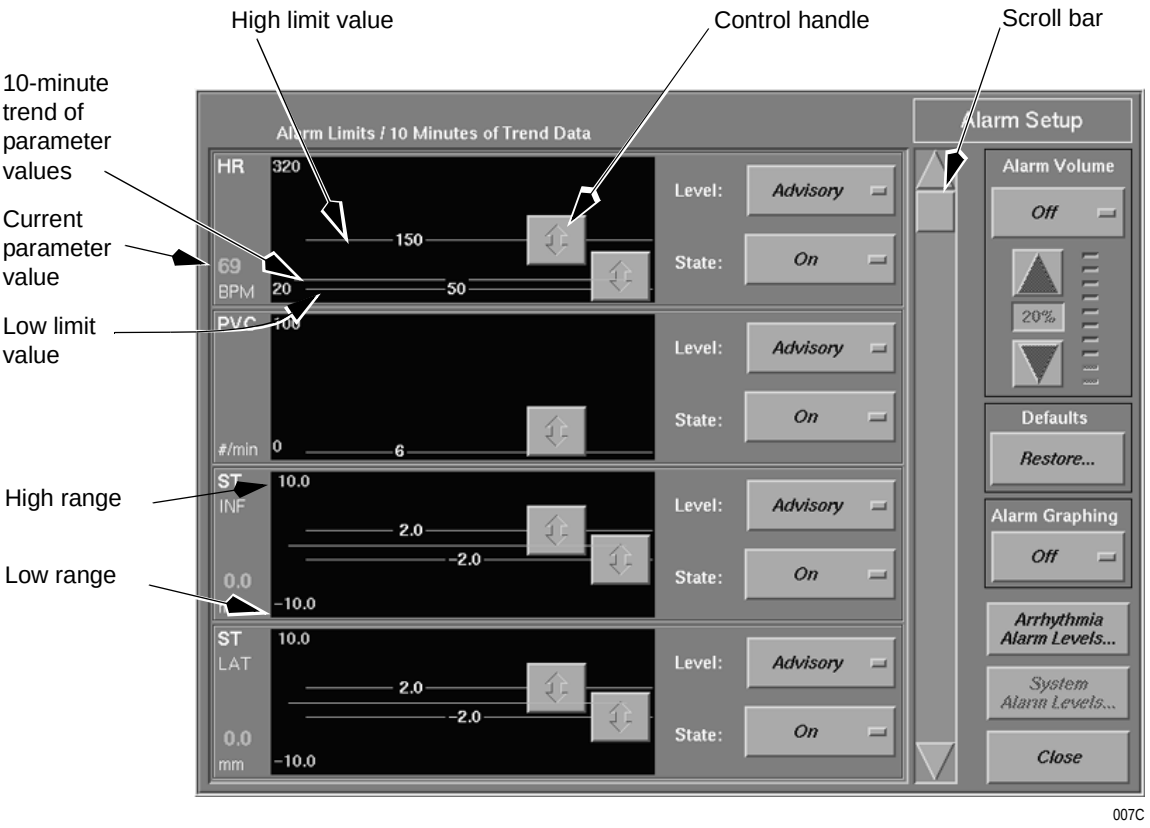
To access the *Alarm Setup* window, select *Alarm Setup...* from the Setups popup menu, or select *To Alarm Setup...* in any of the parameter control windows or procedure windows.

NOTE: If the screen layout you are using has an *Alarm Setup* button, you may also select it to access the *Alarm Setup* window.

When the *Alarm Setup* window is accessed from within a parameter control window, the display automatically scrolls to that parameter's alarm settings. Each parameter alarm window contains the parameter label, its current value, and the unit of measure. The value is updated dynamically and will update as the parameter value is updated in the parameter block.

The *Alarm Setup* window contains alarm limit windows and controls for all parameters. To access the alarm limits window for a parameter that is currently out of view, use the scroll bar to move through the list.

All changes made within the *Alarm Setup* window take place immediately.



Alarm Setup Window

Alarm Limits

095A

Alarm limits are set by selecting the control handle(s) in each monitored parameter's limits window. Touch the control handle to show the up/down icon (see figure at left). Touch the up or down arrows on this icon repeatedly until the limit is positioned appropriately. The current value of the alarm limit is displayed on the limit line.

Alarm Ranges

Alarm ranges are displayed numerically at the left edge of each monitored parameter's limits window.

Alarm Levels

Alarm levels are adjusted by the alarm *Level* popup menu. Alarm level choices are Crisis, Warning, Advisory, and Message.

Alarm On/Off

009A

The *Alarm On/Off* controls enable or disable alarms on an individual parameter basis. When an alarm is disabled, there will be no visual or audible indication of it, and it will not be included in alarm histories.

NOTE: An alarms off indicator (bell icon) is placed in the parameter window when the parameter alarm is disabled.

NOTE: In the service mode, the parameter alarm state can be set to *Always On* as a default. If this has been done, the user does not have the ability to disable the parameter alarms.

Alarm Volume

The *Alarm Volume* control enables or disables the audio for all alarms. The default for all alarms is 20%.

NOTE: A message is displayed at the top of the waveform window if alarm volume is turned off.

NOTE: In the service mode, the alarm volume can be set to *Always On* as a default. If this has been done, the user does not have the ability to turn the alarm volume off.

Alarm Defaults

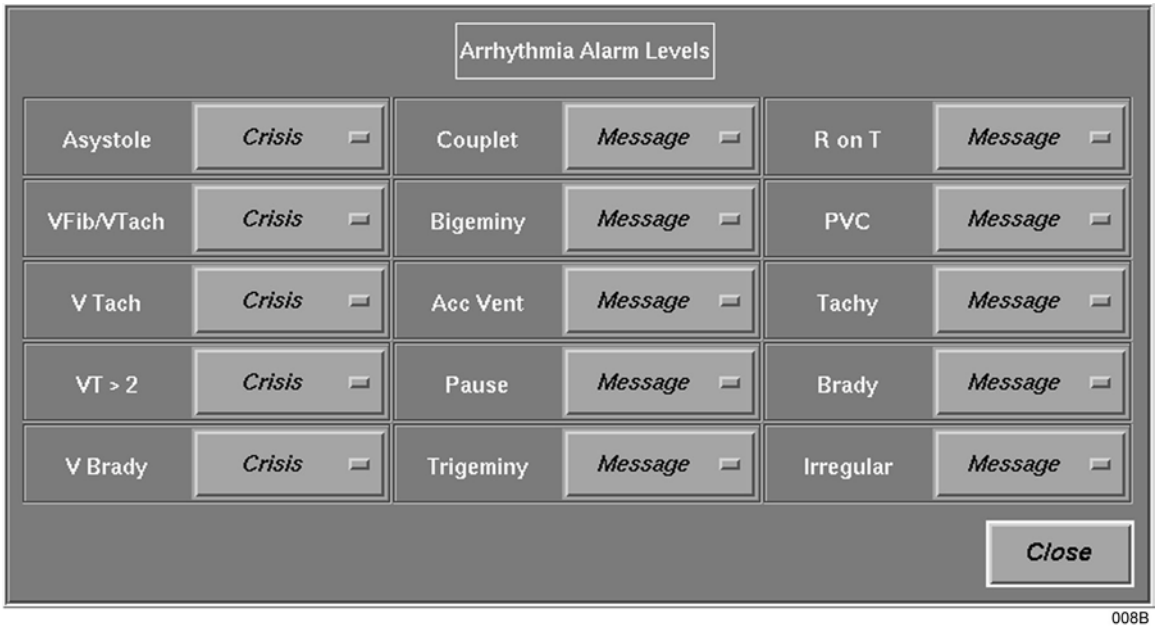
The *Defaults* controls allow you to restore your unit's parameter and arrhythmia alarm setups back to the user defaults. Alarm defaults may be changed in service mode.

Alarm Graphing

The *Alarm Graphing* control enables and disables automatic graphing of alarms as they occur.

Arrhythmia Levels

Selecting *Arrhythmia Alarm Levels...* opens the *Arrhythmia Alarm Levels* window.



***Arrhythmia Alarm Levels* Window**

All of the arrhythmia conditions monitored are listed in this window, with alarm level popup menus next to each condition. Choices in the alarm level popup menus are Crisis, Warning, Advisory, and Message. Use these alarm level popup menus to adjust the arrhythmia alarm level settings.

NOTE: Not all arrhythmias are active, depending on the level of arrhythmia (full, lethal, or off) selected in the *ECG Controls* window.

To close the *Arrhythmia Alarm Levels* window, select *Close*.

System Alarm Levels

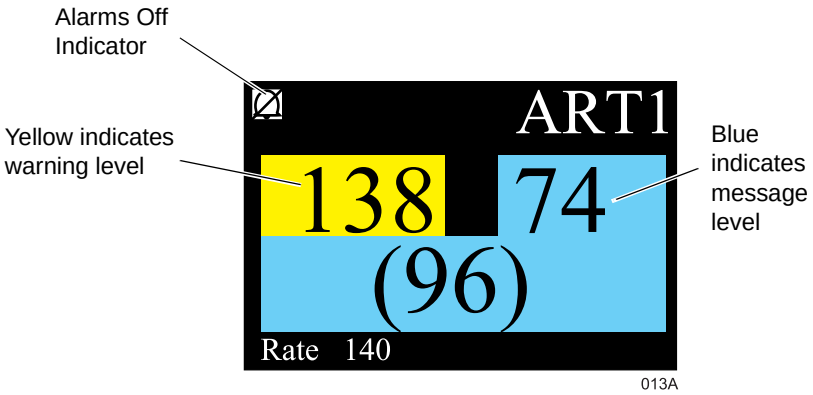
This control is for service mode only. Refer to the service manual for more information.

Close

Select *Close* to close the *Alarm Setup* window.

Alarms Displayed in Parameter Windows

Alarms are triggered when a patient condition exceeds parameter limits. This alarm condition is displayed in the alarming parameter's window.



ART1 Parameter Window

NOTE: Colors are not discernible on black and white manual page.

Alarm conditions are displayed using reverse video on color-coded backgrounds. The color coding corresponds to the alarm level assigned to the parameter in question:

Alarm Level	Background Color	Text
Crisis	Red	White
Warning	Yellow	Black
Advisory	Amber	Black
Message	Blue	Black

Alarms Off Indicator

009A

When the Alarms Off indicator is displayed in a parameter block, at least one individual alarm has been turned off for that parameter.

For your notes

5 Printing

For your notes

General Information

Configuring Printers

The Solar 9500 monitor can be set up to print to a networked or parallel laser printer. It can also be set up to print to a PRN 50-M digital writer. This is done using the *Configure Printers...* button in the Service mode. Selecting this button opens the *Net Printer Setup* window.

NOTE: Laser printers must be true Postscript printers for compatibility with the Solar 9500 monitor.

For more information on configuring printers, please refer to the service manual.

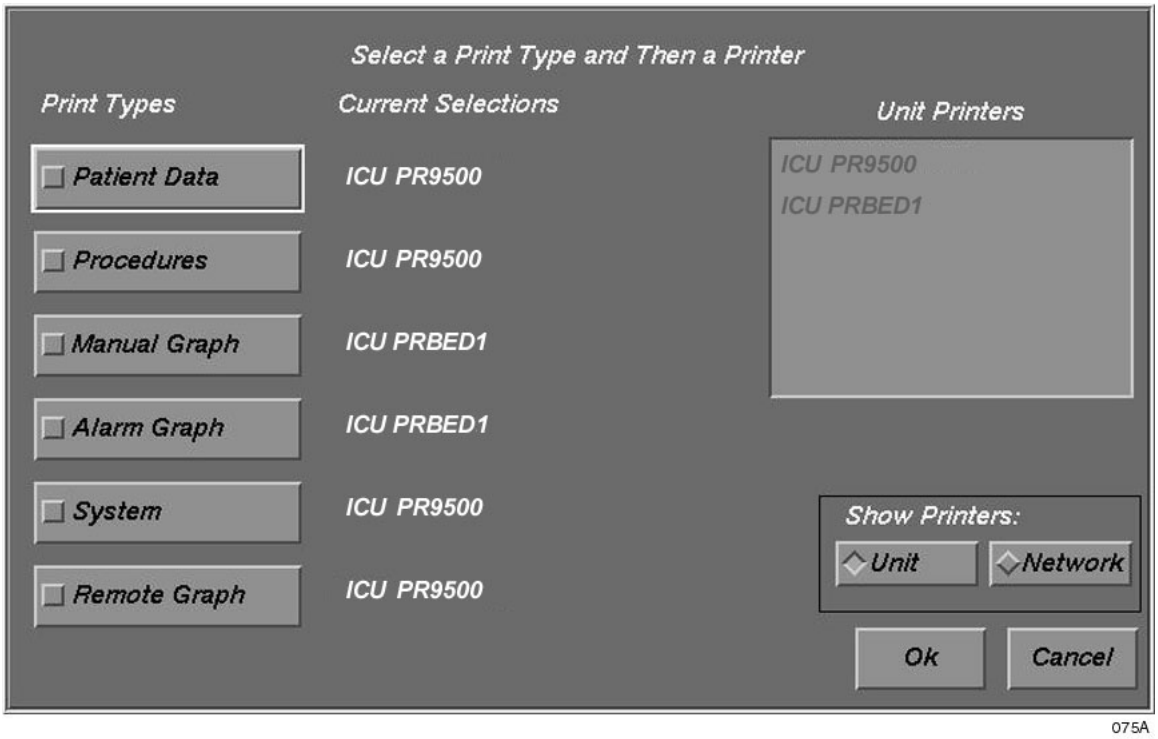
NOTE: The *Net Printer Setup* window is used to configure network printers only.

Parallel printers and PRN 50-M digital writers can be set up using the *Select Printers...* option in the *Setups* menu. They will use the bed's unit and bed name. Printers may take up to 5 minutes to be recognized on the network.

NOTE: The bed name and the unit name must be active (i.e., not blank) for any type of printer to be listed in the Select Printers list.

Selecting a Printer

To designate a print destination for printouts initiated from the monitor, select *Select Printers*... from the Setups lower control menu. Selecting this option opens a window which allows you to assign different printer locations based on print type.



***Select Printers* Window**

Print Types

The print types are listed below.

Patient Data—includes trends, alarm history, cardiac calculations, ST analysis, and end of case printouts.

Procedures—includes catheter insertion, PA wedge, cardiac output, and 12 SL printouts.

Manual Graph—includes printouts initiated by selecting *Start Manual Print* in a waveform window.

Alarm Graph—includes all alarm graph events if enabled in the *Alarm Setup* window.

System—includes all system printouts: software revision, parameter and alarm defaults, and all service mode printouts.

Remote Graph—includes printouts initiated from a remote source such as a clinical information center, central station, or Solar 8000 patient monitor. Refer to “Remote Graphing Information” in this chapter.

Selecting a Print Type

NOTE: The PRN 50-M digital writer is only available for *Manual Graph*, *Alarm Graph*, and *Remote Graph* print types. You must select a laser printer or a network printer for the other print types.

1. To designate a printer for a print type, select an option from the list of print types. After selected, a indicator light will come on next to the print type label.

   NOTE: If multiple print types are selected, and one or more types selected can only be assigned to a laser or networked printer, any PRN 50-M digital writers on the list will temporarily disappear from the list.

   The current printer selection is shown to the right of the print type label.

2. Highlight the desired printer from the *Unit/Network Printers* window.

   NOTE: The *Show Printers...* option toggles the view between available printers in the unit and available printers on the network.

3. Repeat steps 1 and 2 as necessary for the remaining print types.
4. Select *Ok* to activate your changes, or *Cancel* to close the window without making changes.

Remote Graphing Information

All Solar 9500 graphs initiated from a remote source are printed at a printer selected at the Solar 9500 monitor itself.

Graphs of Solar 9500 data which are initiated from a clinical information center, a central station, or a non-Solar 9500 monitor (e.g., Solar 8000M, Solar 8000, Dash 3000) always print to the location selected as the *Remote Graph* location at the Solar 9500 monitor itself. These graphs will NOT print to a printer connected to the remote device. They will only print to a printer selected as the Solar 9500 Remote Graph location.

To find or set up the printer selected as the Remote Graph location, select *Select Printers* from the Setups menu. A window opens, allowing printer selection for several print types. Select the *Remote Graph* button at the bottom of the window to choose the remote graph printer. The name of the printer selected appears next to the *Remote Graph* button.

Manual Graphing

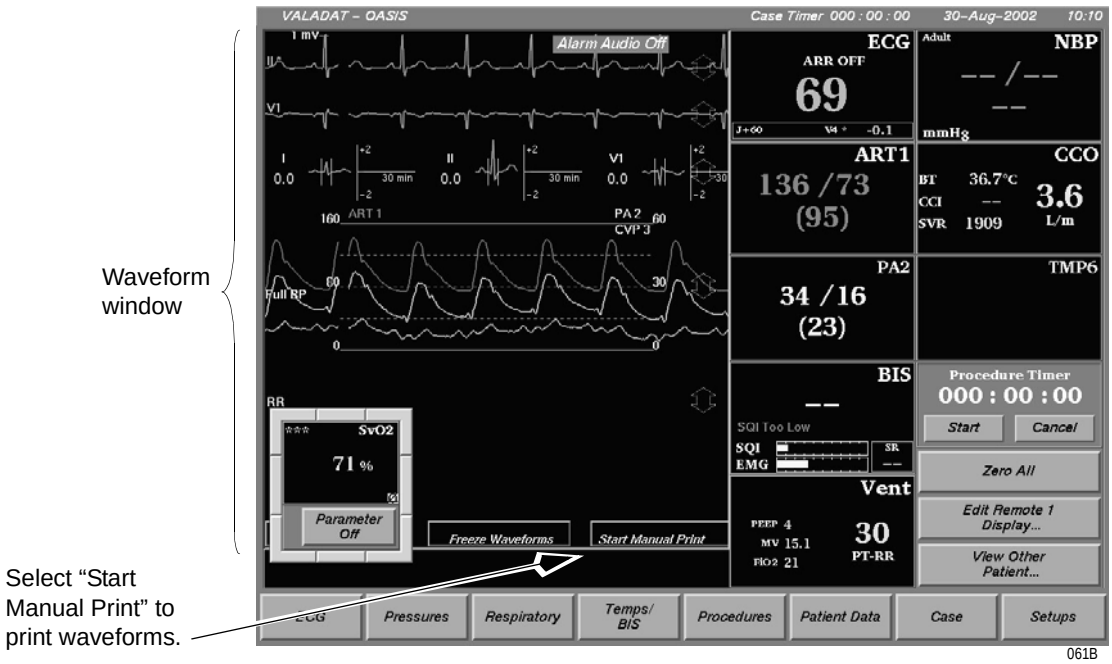
A manual graph can be initiated from any waveform window displayed on the Solar 9500 monitor. Manual graph requests are sent to the printer designated for “Manual Graphs” in the *Select Printers* window.

To print the contents of a waveform window, select *Start Manual Print* along its lower edge. This initiates a real-time print of all of the waveforms in that window. A header is included on this printout, giving all parameter data concurrent with the real-time waveforms.

NOTE: ST information in the waveform window does not print. To print ST templates, select *Print* from within the *ST Analysis* window (refer to the ECG chapter, “ST Analysis Window” on page 9-27).

Only one real-time print can be active at a time. A request to print in one window or an active alarm graph, will stop any printing in another window.

Manual graph requests are ignored when an alarm graph is printing.

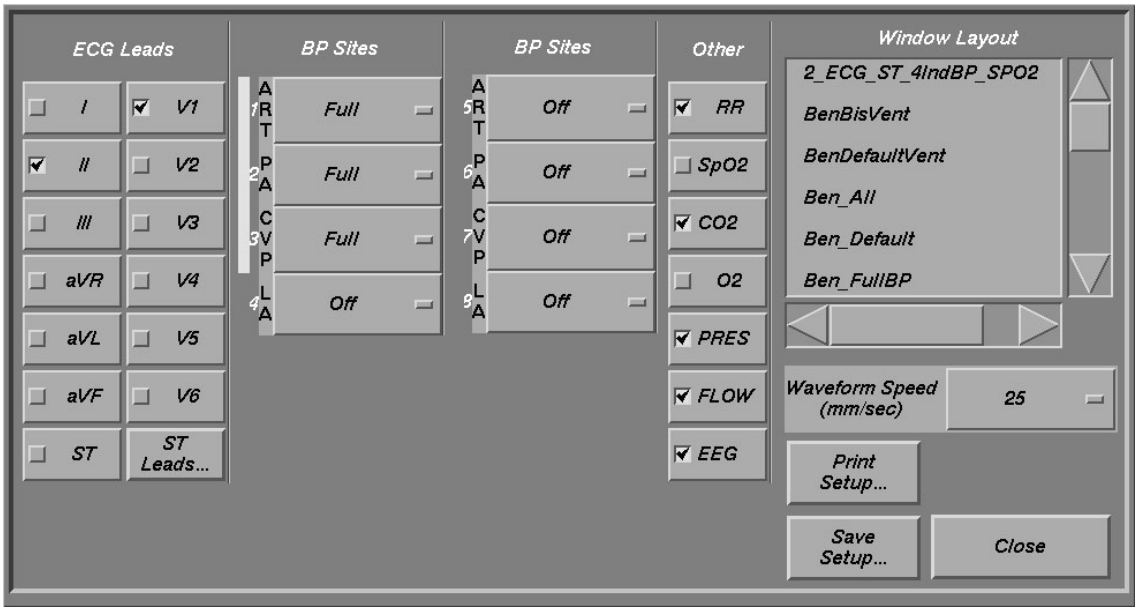


Solar 9500 Information Monitor Display Screen

Manual Graph Setup

Follow these steps to set up waveform window printing configurations.

1. Select *Configure Window*... in the lower left corner of the waveform window. The waveform configuration window opens.

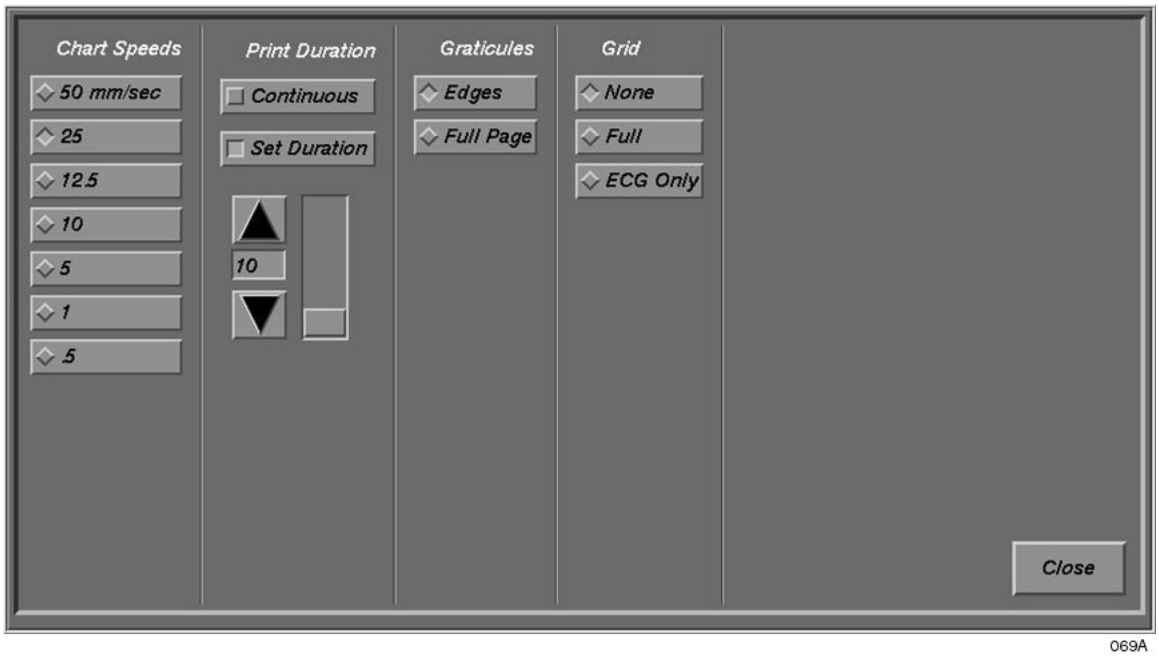


Waveform Configuration Window

2. Select *Print Setup*... to open the print setup window.

Print Setup Window

With the print setup window open, you can select the speed at which you would like the waveforms to print, the duration of the print, and whether or not graticules and grids should be printed.



Print Setup Window

Chart Speeds

From the list of available chart speeds, select the speed at which you would like the waveforms to print (the selected speed label will be illuminated).

NOTE: Alarm graphs print at 25 mm per second.

Print Duration

To choose a print duration, select *Continuous* for a continuous print of waveforms, or select *Set Duration* to manually set the print duration. The light in the selected print duration label will be illuminated. The duration defaults to a value that represents a one-page printout.

To manually set the print duration, use the up/down arrows or the slider control to increase or decrease the print duration value. The current value is displayed. The range of print duration is 5 to 500 seconds.

If the print duration is set to *Continuous*, you must select *Printing* again to stop the print.

NOTE: Manual graph requests are ignored when an alarm graph is printing.

Graticules

To print graticules only at the edges of the page, select *Edges*. To print graticules across the full page, select *Full Page*. The light in the selected graticules label will be illuminated.

NOTE: This option does not affect any printouts from a PRN 50-M digital writer.

Grid

To print a grid for all waveforms, select *Full*. To print a grid for ECG waveforms only, select *ECG Only*. If you do not want a grid to appear on any printouts, select *None*. The light in the selected grid label will be lit.

NOTE: This option does not affect any printouts from a PRN 50-M digital writer.

Close

Select *Close* to exit the print setup window.

Saving a Print Configuration

After you have adjusted the settings in the print setup window and returned to the waveform configuration window, you can save the settings for future use.

1. Select *Save Setup...* to open the *Save Waveforms Layout* dialog window.
2. Name the waveform layout to be saved.
3. Select *OK* to save the waveform layout, or *Cancel* to close the dialog window without saving.

   NOTE: Naming and selecting *OK* to save a layout saves all of the settings within the waveform configuration window, not just the print setup settings.

4. Close the waveform configuration window.

Alarm Graphing

Alarm graphs are sent to the printer designated for “Alarm Graphs” in the print setup window.

Automatic Graphing

The automatic graph on alarm feature can be enabled or disabled in the Alarm Setup window. For automatic graphing on alarm to occur, Alarm Graphing must be turned on in the Alarm Setup window, and the violating arrhythmias or parameters must be classified as Warning or Crisis.

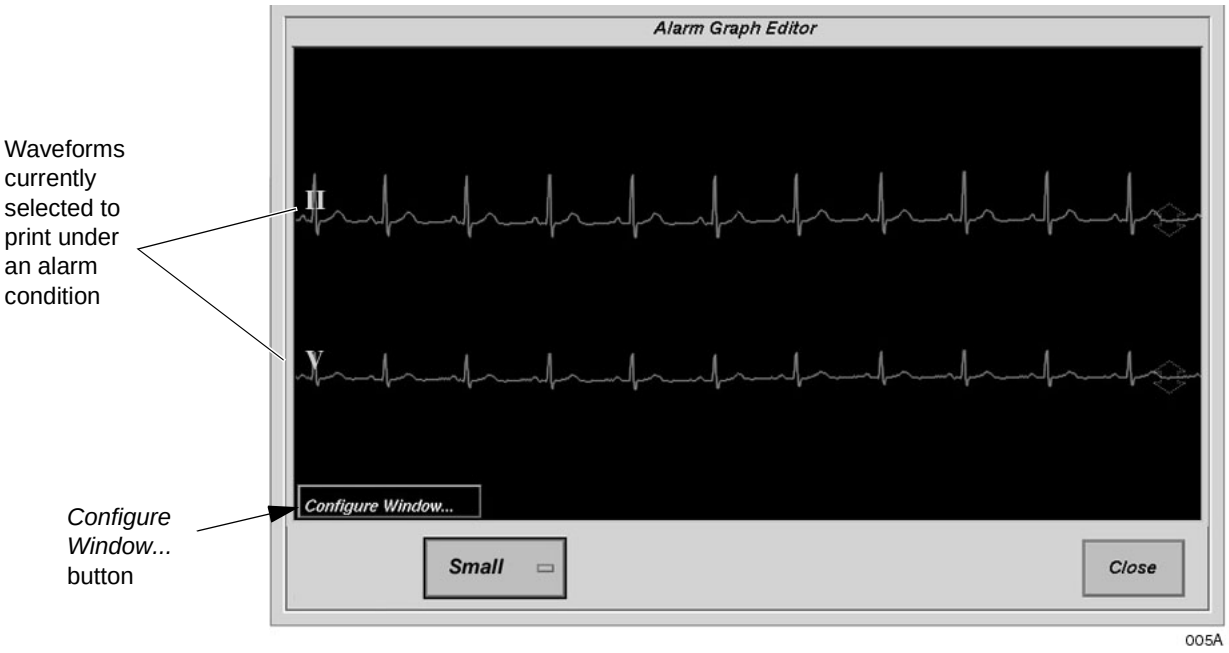
When an alarm graph is printing, the message *ALARM Graphing* is displayed in the waveform window print button.

NOTE: When arrhythmia alarm graph printing is set to end of event, manual graph requests are ignored while an alarm graph is printing.

Alarm Graph Setup

Select *Alarm Graph Setup...* from the *Setups* popup menu to configure the printout for alarm printing.

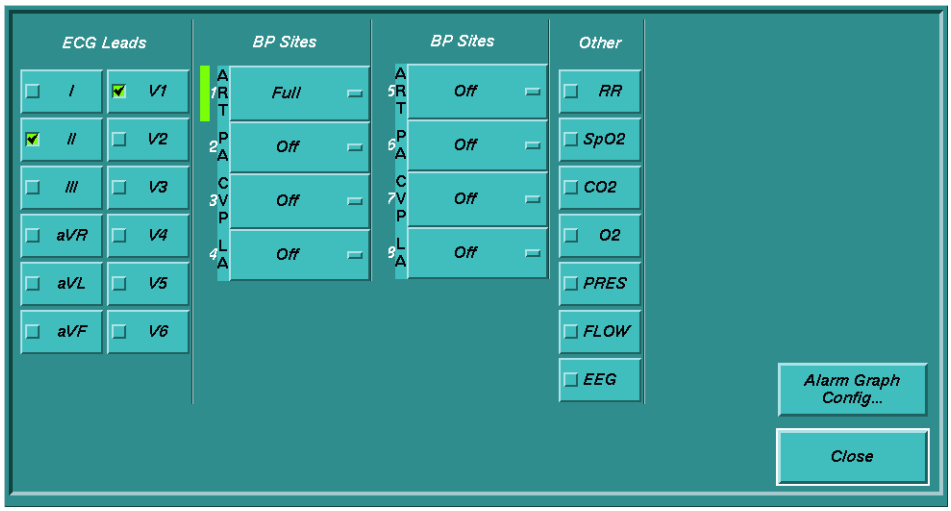
The *Alarm Graph Editor* window opens, allowing you to configure alarm graph settings.



***Alarm Graph Editor* Window**

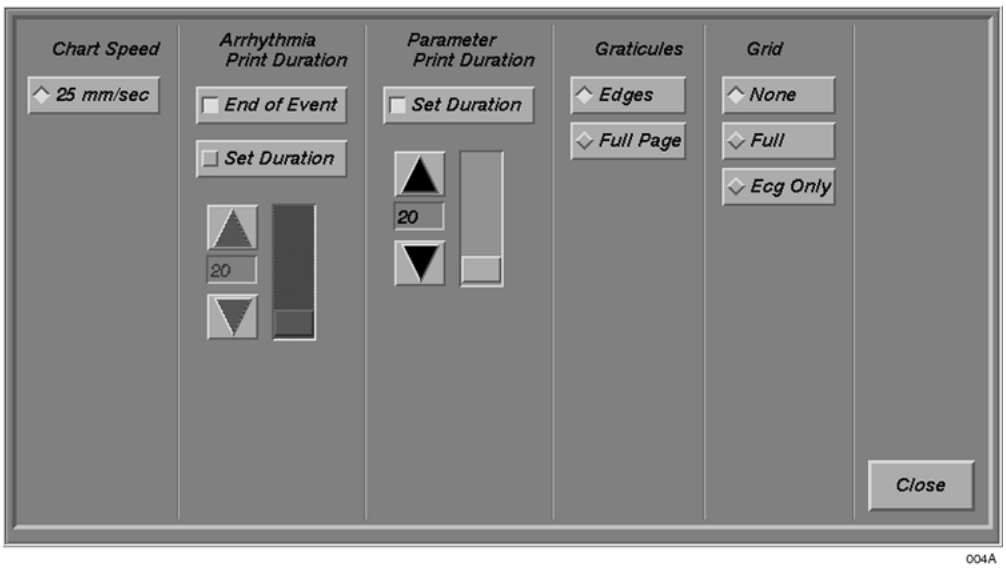
Configuring the Alarm Graph Editor Window

Select *Configure Window...* from the *Alarm Graph Setup* window to open the control window which allows customization of alarm graphs.



204B

- *ECG Leads*—Allows you to designate which leads will be displayed in the *Alarm Graph Editor* window and on the alarm graph.
- *BP Sites*—Allows you to designate the blood pressure information to be displayed in the *Alarm Graph Editor* window and on the alarm graph.
- *Other*—Allows you to designate the parameter information to be displayed in the *Alarm Graph Setup* window and on the alarm graph.
- *Alarm Graph Config...*—Opens the alarm graph configuration window, where you will determine settings for the *Alarm Graph Editor* window and the alarm graph.



004A

Chart Speed

The chart speed for alarm graphs is fixed at 25 millimeters per second. It cannot be changed.

Print Duration

To choose a print duration for arrhythmia alarm graphs, select *End of Event* or *Set Duration*.

End of Event—This alarm print will capture the 20 seconds prior to the event through ten seconds after the event is resolved.

NOTE: The *End of Event* option is available only for arrhythmia alarms. Graphing for all other alarm events will have a fixed duration (to be set by the user).

Set Duration—This alarm print will capture the 20 second prior to the event and will continue until the end of the set duration. To manually set the print duration, use the up/down arrows or the slider control to increase or decrease the print duration value. The current value is displayed.

To choose a print duration for parameter alarm graphs, select *Set Duration* (refer to description above). The default duration is 20 seconds.

Graticules

To print graticules only at the edges of the page, select *Edges*. To print graticules across the full page, select *Full Page*. The light in the selected graticules label will be illuminated.

NOTE: This option does not affect any printouts from a PRN 50-M digital writer.

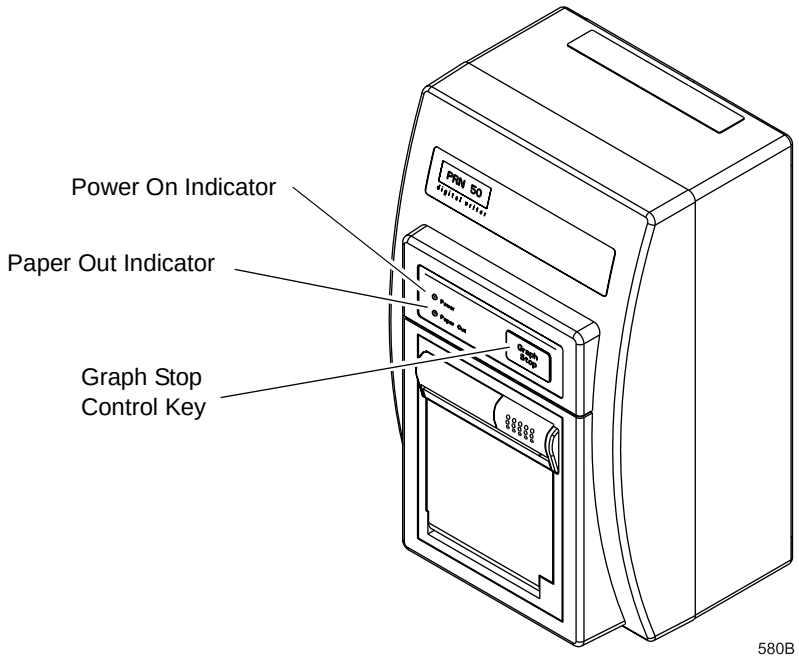
Grid

To print a grid for all waveforms, select *Full*. To print a grid for ECG waveforms only, select *Ecg Only*. If you do not want a grid to appear on any printouts, select *None*. The light in the selected grid label will be illuminated.

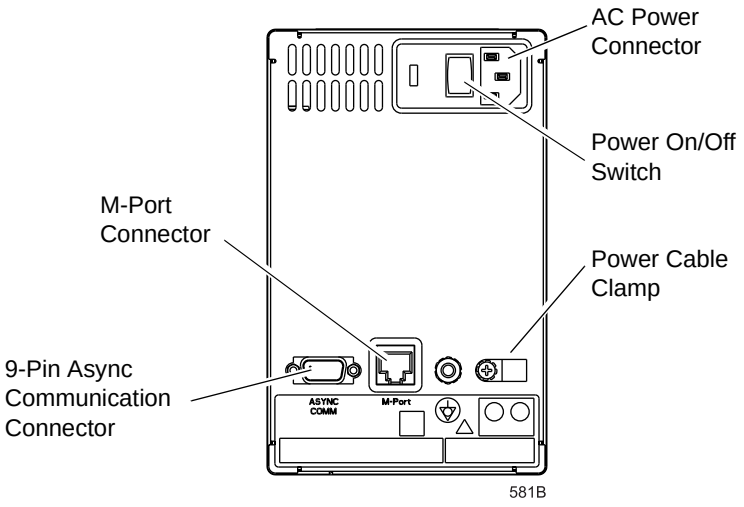
NOTE: This option does not affect any printouts from a PRN 50-M digital writer.

PRN 50-M Digital Writer

The optional PRN 50-M is connected by cable to the monitor. It uses 2-inch paper. There are two indicator lights and one control key on the front. The power switch and connectors are on the back.



Front View of the PRN 50-M Digital Writer

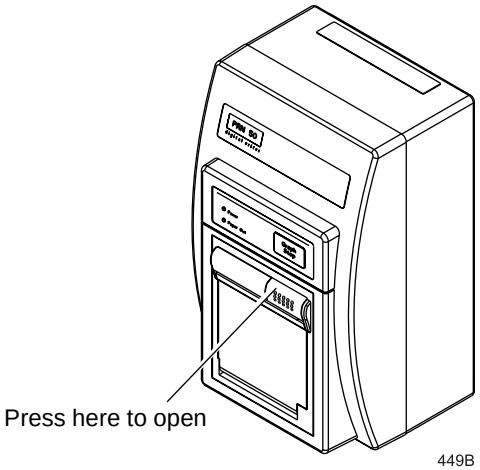


Back View of the PRN 50-M Digital Writer

NOTE: The PRN 50-M digital writer connects to the Solar 9500 monitor via the M-Port connector on the back of the writer and the M-Port connector (or one of the serial ports) on the Solar 9500 monitor. Refer to the *Solar 9500 Information Monitor Service Manual* for more details on interconnections.

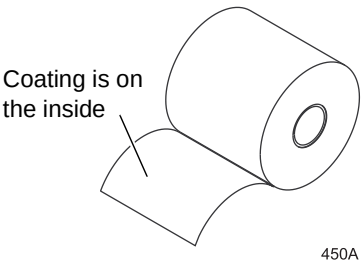
Changing the PRN 50-M Digital Writer Paper

1. Open the door by pressing on the top of the door, as indicated below.



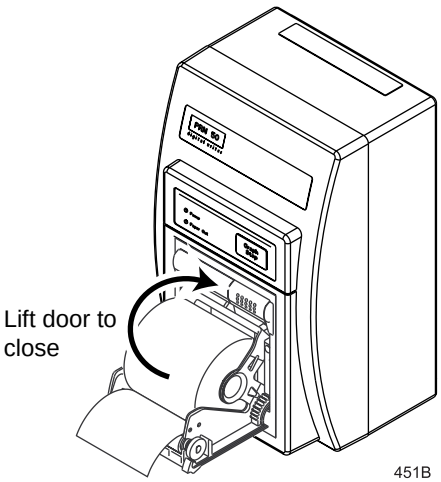
449B

2. Remove the old paper spool and install a new roll. The paper contains a special coating on one side and must be installed correctly. Install the paper so it unrolls from the bottom.



450A

3. Close the door and make sure the paper protrudes through the opening.
4. Test the writer by starting a graph strip.



451B

NOTE: If the graph strip is blank, the paper is probably installed upside down. Turn the spool over so the paper unwinds from the top.

Troubleshooting

Following are some problems that may occur when printing.

NOTE: All print jobs are queued and will continue to be generated even when a printer is not available. The print jobs will resume printing when the printer becomes available again. No print data is lost.

Problem: You are unable to print to your selected printer.

Cause: The printer you have selected is unavailable for use.

Solution: A message box opens alerting you to the printer's unavailability and directing you to the *Select Printers* menu option found in the *Setups* popup menu. The previously queued printout will now go to the second printer.

Choose *Select Printers...* from the Setups popup menu and select another printer. Check the first printer.

NOTE: If the original printout was sent to a laser printer, only a laser printer can be selected as the new printer. Likewise, if the original printout was sent to a PRN 50-M digital writer, only a PRN 50-M digital writer can be selected as the new printer.

Problem: You are having problems sending a file to the printer.

Cause: The printer has stopped accepting data. It may be out of paper, jammed, otherwise unusable, or just very slow.

Solution: Check the printer to make sure it is on-line, has paper, is not jammed, or experiencing any other problem.

For your notes

6 Patient Data

For your notes

Introduction

The *Patient Data* popup menu provides quick access to the following options:

Trends...

Cardiac Calcs...

Alarm History...

Arrhythmia Review...

ST Analysis...

Patient Info...

View Other Patient...

Browser...

Selecting any of these options from the *Patient Data* popup menu will open the corresponding window. These windows may be moved to a new position on the display or moved to another display.

NOTE: The *Arrhythmia Review...* and *Browser* options are user purchased options. If your institution has not purchased them, they will not appear in the popup menu.

Trends

Upon the start of a case, a history of the patient's vital signs is continually collected. The trended vital signs data can be viewed in table format, as tabular trends. Another format for displaying collected patient data is through graphic trends. A trend is a representation of one parameter over a specified period of time.

Storage of Trend Data

Trend data storage is started when a valid ECG signal or a valid heart rate is determined from a SpO2 signal. Once started, trend data storage continues indefinitely or until the case is ended via the *End Case...* option in the *Case* popup menu, with the *Delete Patient Data* option enabled. Trend data is stored for any parameter active in the last 24 hours. Missing data from unmonitored parameters will be blanked.

Every non-episodic parameter is sampled every two seconds. A median value is determined and that value is stored for trend display at one-minute resolution. Episodic parameters (NBP, etc.) are stored every time one occurs. If more than one episodic event occurred during the same minute, the more recent event will overwrite the earlier one.

You cannot change any trended values, but you can use the controls to view all the data collected.

Accessing the Trends Window

To view a patient's trends, select the *Patient Data* lower control button. Choose *Trends* from the popup menu that appears.

Additionally, these windows may be moved to a new position on the display or moved to another display.

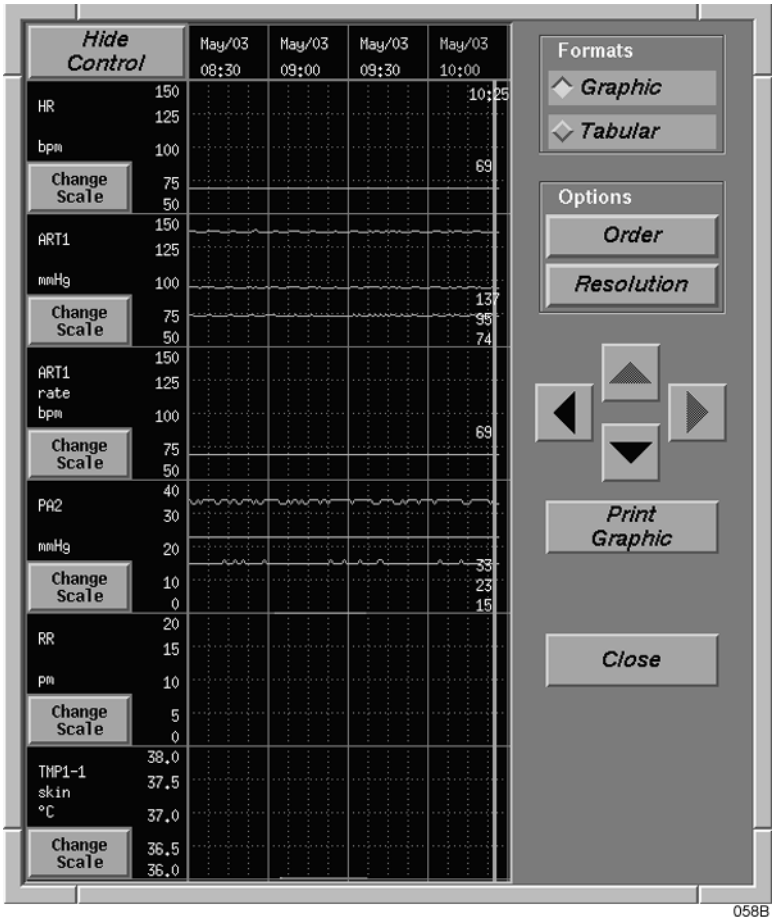
The trend window defaults with a display of graphic trends, but will return to the last selected view of trend data.

Display Format

Trends allow you to view vital signs in graphic format and tabular (numerical) format.

To select a graphic trend, select the *Graphic* button from the *Formats* choices located at the right side of the trend window. To select a tabular trend, select *Tabular* from the *Formats* choices located at the right side of the trend window.

Graphic Trends



Graphic Trends Window

When graphic trends are displayed, information is plotted in amber. The exceptions to this are as follows:

- When data is trended that has two values, such as inspired and expired gas, the inspired values will be plotted with an amber line, and the expired values will be plotted with a white line. On a printout, the expired values will be dotted.
- When trended data for a parameter is out of scale, it will be plotted in red. Since most printing will not be in color, when trended data is out of scale, asterisks "*" will be printed. When episodic parameter values are out of scale, "?" will be printed.
- Missing data resulting from unmonitored conditions will be blanked.

Graphic Trends Controls

The options located at the right edge of the trend window are the same for both graphic and tabular trends. These options are *Order*, *Resolution*, *Print*, and *Close*. Additionally, there is a movable cursor and arrow keys which allow you to scroll through information on the trend displays.

Order

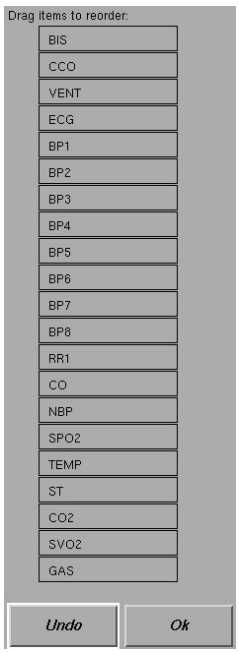
Trends can display data in different orders. The choices for order are *All data*, *NBP*, *Cardiac Calcs*, and *Your own*. To choose an order, highlight your choice from the list of options.

All Data—displays all of the available trended data in a factory default order.

NBP—displays NBP trend data first, then the rest of the trend data. The trend data shown is from the exact times of NBP measurement only, including all other trend data from those exact times also.

Cardiac Calcs—displays cardiac calculations data first, then the rest of the trend data. The trend data shown is from the exact times of cardiac calculations only, with all other trend data from those exact times. For more information on trends sorted to Cardiac Calcs order, refer to the "Cardiac Calcs" section in this chapter.

Your Own—allows you to define your own order for displaying trend information. To set your own display order, highlight *Your Own*. A popup window opens that contains boxes labeled with names of all of the parameter groups for display in trends. Move these labeled boxes around by touching and dragging or by selecting with the mouse and dragging until the order displayed suits your needs. Select *Ok* to confirm the new order, or select *Undo* to erase your changes.



Your Own Popup Menu

Resolution

The choices of resolutions in which to view a graphic trend are *1 Min*, *2 Min*, *4 Min*, *8 Min*, and *16 Min*. The default resolution is 1 minute for graphic trends.

To set the trends display resolution, select *Resolution* to show a list of time choices. Highlight your choice from the list of options.

Arrow Buttons

The arrow buttons allow movement around the *Trends display* window.

Moves the selection left one page.

Moves the selection right one page.

Moves the selection up one page.

Moves the selection down one page.

Show Control/Hide Control

After the settings for viewing the trend suit your needs, you can expand the trend window by hiding the controls. Selecting the *Show Control/ Hide Control* button in the top left corner of the trends display window will expand or reduce the area of the window designated for trend information.

Select *Hide Control* to expand the trend information area and to hide the trend control buttons at the right edge of the trends display window.

Select *Show Control* to shrink the trend information area and to redisplay the trend control buttons when you need to modify the trend settings.

Print

Print Graphic

NOTE: If the graphic trend display is sorted to Cardiac Calcs order, only Cardiac Calcs information will print.

Select *Print Graphic* to initiate a printout of what is currently shown in the Trends window. An intermediate window will open allowing you to select the duration of the printout, and mark the parameters for which trend data will be printed.

NOTE: If a parameter is marked for printing, a P is shown next to the parameter label.

You can also define the duration of the printout. Select *Duration* to open a list of available options: *Case*, *1 Hr*, *2 Hrs*, *4 Hrs*, *8 Hrs*, *12 Hrs*, and *24 Hrs*. The default duration selection is *Case*.

Case—When *Case* is selected, all available parameters are marked for printing. You can either select *Print* to print everything for the entire case, or you can deselect the parameters for which you do not want graphic trend printouts.

NOTE: If any of the other durations options are selected, none of the available parameters are marked for printing. You must select which parameters you want to include in the graphic trend printout. Otherwise the *Print* button is not available.

Change Scale

Each parameter displayed in the *Graphic Trends* window has a *Change Scale* control. This enables you to scroll through a list of preset scale choices for each parameter.

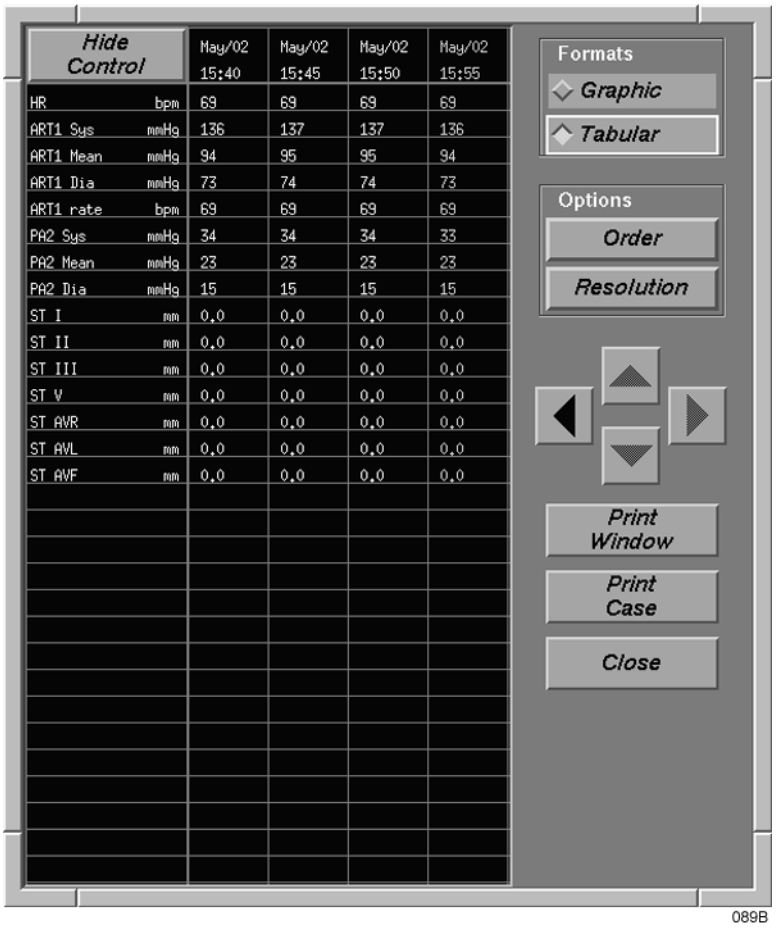
Cursor

A vertical cursor is available to scan through graphic trends. Touch or click on the cursor to move its position on the display. As the cursor scrolls over data points, the time and corresponding data value is displayed.

Close

Select *Close* to close the graphic trends display.

Tabular Trends Display


Hide Control
May/02 15:40
May/02 15:45
May/02 15:50
May/02 15:55
HR bpm 69 69 69 69
ART1 Sys mmHg 136 137 137 136
ART1 Mean mmHg 94 95 95 94
ART1 Dia mmHg 73 74 74 73
ART1 rate bpm 69 69 69 69
PA2 Sys mmHg 34 34 34 33
PA2 Mean mmHg 23 23 23 23
PA2 Dia mmHg 15 15 15 15
ST I mm 0.0 0.0 0.0 0.0
ST II mm 0.0 0.0 0.0 0.0
ST III mm 0.0 0.0 0.0 0.0
ST V mm 0.0 0.0 0.0 0.0
ST AVR mm 0.0 0.0 0.0 0.0
ST AVL mm 0.0 0.0 0.0 0.0
ST AVF mm 0.0 0.0 0.0 0.0
Formats
Graphic
Tabular
Options
Order
Resolution
Print Window
Print Case
Close
089B

Tabular Trends Window

For tabular trends, the most recent data and the oldest data, with corresponding header information (date and time) will appear in amber. All other information will be white.

Tabular Trends Controls

The options located at the right edge of the trend window are the same for both graphic and tabular trends. These options are *Order*, *Resolution*, *Print*, and *Close*. Additionally, there is a movable cursor and arrow keys which allow you to scroll through information on the trend displays.

Order

Trends can display data in different orders. The choices for order are *All data*, *NBP*, *Cardiac Calcs*, and *Your Own*. To choose an order, highlight your choice from the list of options.

NOTE: For episodic parameters, such as NBP and cardiac calcs, only the intervals that contain data are shown.

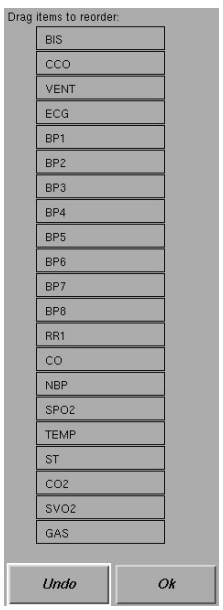
All Data—displays all of the available trended data in factory default order.

NBP—displays only columns which contain NBP values. The row order displays NBP trend data first, then the rest of the trend data.

Cardiac Calcs—displays only columns which contain cardiac calculations values. The row order displays cardiac calculations trend data first, then the rest of the trend data.

For more information on trends sorted to Cardiac Calcs order, refer to “Cardiac Calcs” in this chapter.

Your Own—allows you to define your own order for displaying trend information. Highlight *Your Own*. A popup window opens that contains boxes labeled with names of all of the parameters groups for display in trends. Move these labeled boxes around by touching and dragging or by selecting with the mouse and dragging until the order displayed suits your needs. Select *Ok* to confirm the new order, or select *Undo* to erase your changes.



Your Own Popup Menu

Resolution

The choices of resolutions in which to view a tabular trend are *1 Min*, *5 Min*, *10 Min*, *15 Min*, and *30 Min*. The default resolution is 5 minutes for tabular trends.

To set the trends display resolution, select *Resolution* to show a list of time choices. Highlight your choice from the list of options.

Arrow buttons

The arrow buttons allow movement around the *Trends display* window.

Moves the selection left one page.

Moves the selection right one page.

Moves the selection up one page.

Moves the selection down one page.

Show Control/Hide Control

After the settings for viewing the trend suit your needs, you can expand the trend window by hiding the controls. Selecting the *Show Control/ Hide Control* button in the top left corner of the trends display window will expand or reduce the area of the window designated for trend information.

Select *Hide Control* to expand the trend information area and to hide the trend control buttons at the right edge of the trends display window.

Select *Show Control* to shrink the trend information area and to redisplay the trend control buttons when you need to modify the trend settings.

Print

Print Window

NOTE: If the tabular trend display is sorted to Cardiac Calcs order, only Cardiac Calcs information will print.

Select *Print Window* to initiate a printout of what is currently shown in the Trends window.

Print Case

Select *Print Case* to open an intermediate window containing a popup choice list of interval options for printing tabular trends. Choices are *1min*, *5mins*, and *10mins*. Highlight the desired interval, and select *Print* to close the Print Case window and initiate the printout, or *Close* to close the Print Case window without making changes.

Close

Select *Close* to close the tabular trends display.

Managing Trend Data

Parameter data is stored in trends for a maximum of 24 hours. After 24 hours have elapsed, the oldest data is deleted to accommodate newer trend data.

Recovering Trends Data

If a power outage should occur in the middle of a case, trend data will be accessible when the system restarts, as long as the data is not older than 24 hours. New trend data will be displayed as a continuation of the trend, with no data displayed for the time period that the system was down.

NOTE: Trend data older than 24 hours cannot be retrieved.

End of Case

At the end of a case, in the *End Case* popup menu, you are presented with the option of deleting all patient data. If *Delete Patient Data* is highlighted, all trend data will be deleted from the system, along with all other patient data (alarm histories, cardiac calcs, etc.). For more information, refer to Case in Chapter 1, The Basics.

Print Case

At the end of a case, in the *End Case* popup menu, you are presented with the options *Print Graphic Trends* and *Print Tabular Trends*. If either or both of these options are selected, the corresponding trend data will print according to the print settings selected within the Trends window. For more information on printing graphic trends, refer to Graphic Trends Controls, Print, earlier in this chapter. For more information on printing tabular trends, refer to Tabular Trends Controls, Print, earlier in this chapter.

Tram Module Trend Data Transfer

Trend data acquired by a Tram module prior to its being connected to the Solar 9500 monitor is accessible by the Solar 9500 monitor.

Solar 9500 trend data (for parameters not supported by the Tram module) will transfers into the module to allow data to be transported to other monitors.

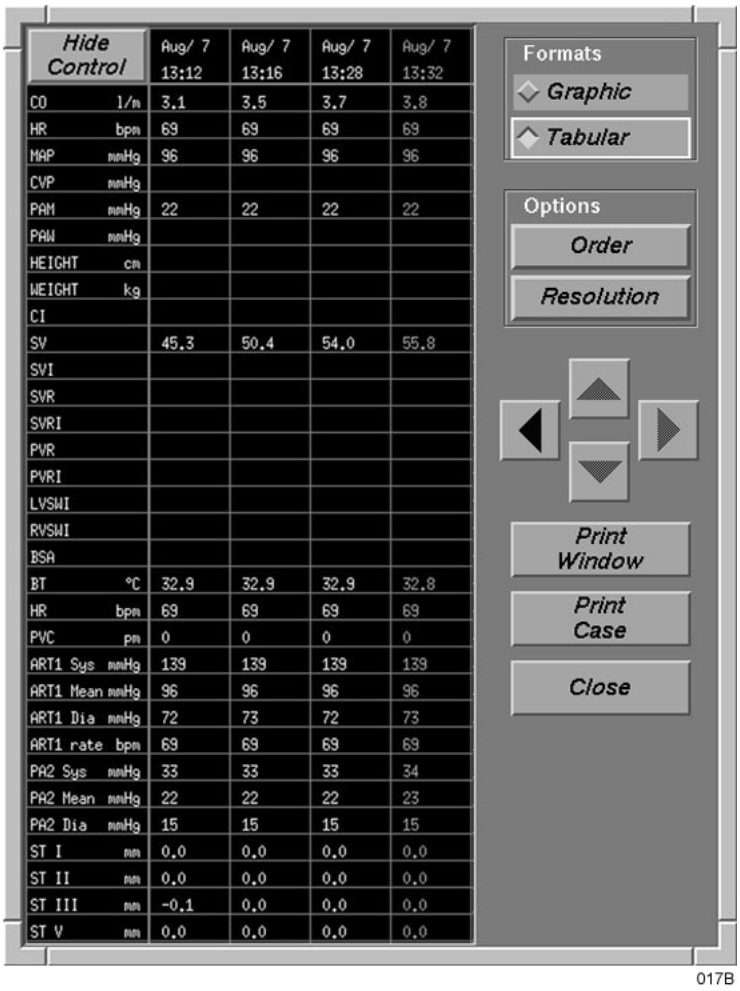
NOTE:

Parameters not supported by the Solar 9500 will not be available for viewing or printing at the Solar 9500 (locally). This data will however, be available at the CIC (on the network).

Cardiac Calcs

Selecting *Cardiac calcs...* from the *Patient Data* popup menu opens the trends display with the data sorted to cardiac calculations. This window is resizeable and movable, and it may be placed on any of the connected displays.

NOTE: Selecting *Cardiac Calcs...* from the *Patient Data* popup menu yields the same results as selecting *Cardiac Calcs* from the *Order* popup menu within the *Trends* window.



Cardiac Calcs Trends Display

Display Format

In graphic format, all vital signs data will display with cardiac calcs data at the top.

In tabular format, only the intervals which contain cardiac calcs data will be shown.

Controls

All of the controls in the cardiac calcs trends display function the same as those in the trends display. If Cardiac Calcs trends are displayed graphically, refer to Graphic Trends Controls in this chapter. If Cardiac Calcs trends are displayed in tabular format, refer to Tabular Trends Controls in this chapter.

Cardiac Calcs Table

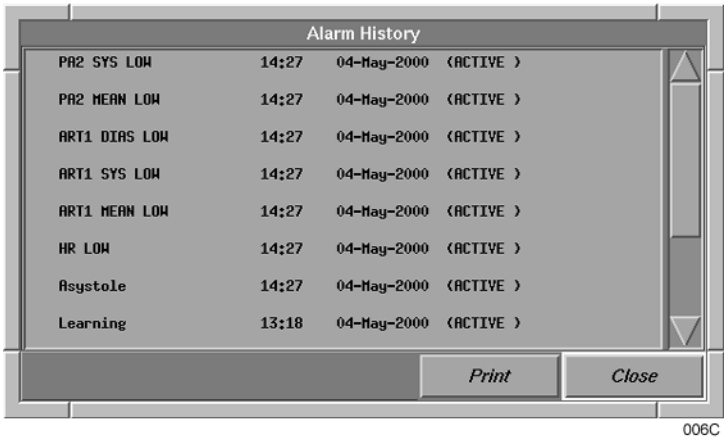
The cardiac calculations are stored from the cardiac output display. A table will be displayed with the measured and calculated values for each trial and a column with the averaged data.

For more information on the Cardiac Calcs table, refer to Cardiac Calcs in Chapter 13, Cardiac Output Monitoring.

Alarm History

To view a patient's alarm history, select *Alarm History*... from the *Patient Data* popup menu.

The patient's alarm history window is displayed. This window is resizeable and movable, and it may be configured for viewing on any of the connected displays.


Alarm History
PA2 SYS LOW 14:27 04-May-2000 (ACTIVE)
PA2 MEAN LOW 14:27 04-May-2000 (ACTIVE)
ART1 DIAS LOW 14:27 04-May-2000 (ACTIVE)
ART1 SYS LOW 14:27 04-May-2000 (ACTIVE)
ART1 MEAN LOW 14:27 04-May-2000 (ACTIVE)
HR LOW 14:27 04-May-2000 (ACTIVE)
Asystole 14:27 04-May-2000 (ACTIVE)
Learning 13:18 04-May-2000 (ACTIVE)
Print
Close
006C

***Alarm History* Window**

This window displays the following information:

- Alarm
- Time in hours and minutes
- Date
- Alarm state when the alarm occurred

Use the scroll bar at the right edge of the window to view all of the alarms recorded in the patient's alarm history.

NOTE: The *Alarm History* window holds a maximum of 100 messages. No waveforms are stored.

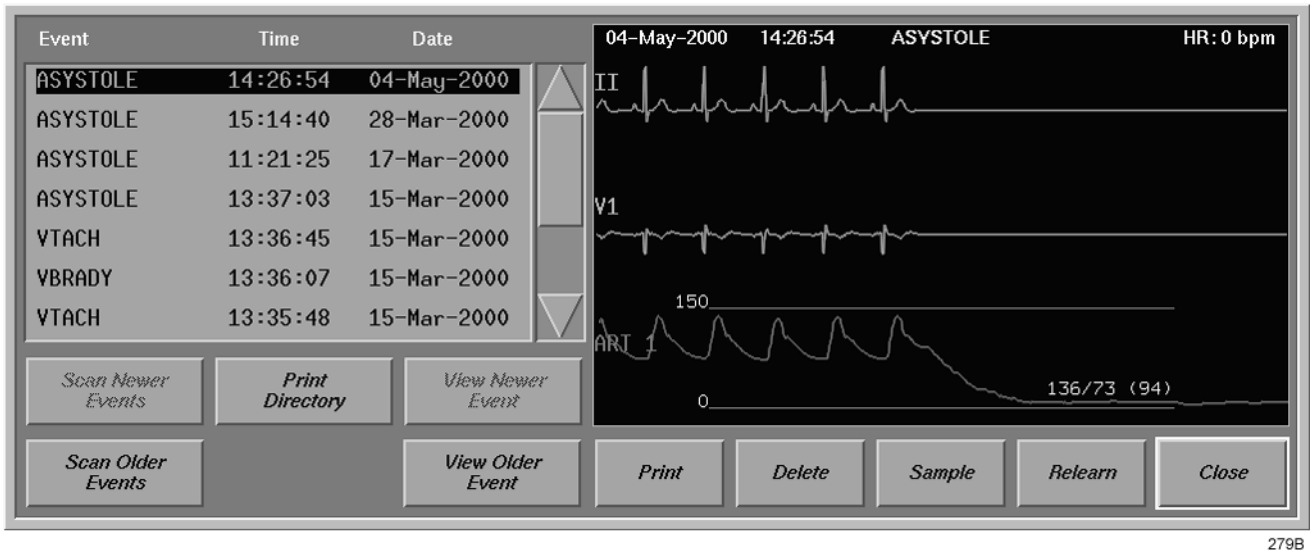
Select *Print* to print the patient's alarm history, or select *Close* to close the *Alarm History* window.

NOTE: All data will be cleared from the *Alarm History* window when an *End Case* is performed with the *Delete Patient Data* option selected.

Arrhythmia Review

NOTE: *Arrhythmia Review...* is a user purchased option.

Selecting *Arrhythmia Review...* from the *Patient Data* popup menu opens the arrhythmia review window. This window is movable, and may be configured for viewing on any of the connected displays.



Arrhythmia Review Window

Arrhythmia review stores and displays a 10-second snapshot of up to 36 arrhythmias. These arrhythmias are listed in the event directory window. The arrhythmia waveform window displays up to three waveforms of data:

- Three ECG waveforms (if there is no active arterial line), or
- Two ECG waveforms and one arterial line waveform.

You can select any stored arrhythmia listed in the event directory and display it in the arrhythmia waveform window or print it on a laser printer.

Arrhythmia Data Controls

Scan Newer Events

Select *Scan Newer Events* to automatically display a slide show of the newer stored arrhythmia events in the arrhythmia waveform window (every 2 seconds).

This button changes to *Stop* when a scan is in process. Select it or select *Scan Older Events* to stop the scan.

Scan Older Events

Select *Scan Older Events* to automatically display a slide show of the older stored arrhythmia events in the arrhythmia waveform window (every 2 seconds).

This button changes to *Stop* when a scan is in process. Select it or select *Scan Newer Events* to stop the scan.

Print Directory

Select *Print Directory* to print the directory of stored arrhythmia events to a laser printer.

View Newer Event

Select *View Newer Event* to manually display a newer stored arrhythmia in the arrhythmia waveform window.

View Older Event

Select *View Older Event* to manually display an older stored arrhythmia in the arrhythmia waveform window.

Print

Select *Print* to print the selected arrhythmia waveform on a laser printer.

Delete

Select *Delete* to delete the highlighted event from the arrhythmia event directory.

Sample

Select *Sample* to store one real-time sample of ECG data viewed in the ECG waveform window. This sample is added to the arrhythmia event directory. Only one sample can be stored at a time. The old sample is replaced by the new sample.

Relearn

Select *Relearn* to relearn the patient's current QRS pattern.

Close

Select *Close* to close the *Arrhythmia Review Control* window.

ST Analysis

Selecting *ST Analysis...* from the *Patient Data* popup menu opens the *ST Analysis* window. This window is movable, and may be configured for viewing on any of the connected displays.

This window displays the seven leads of ST information, grouped according to their lead groups.

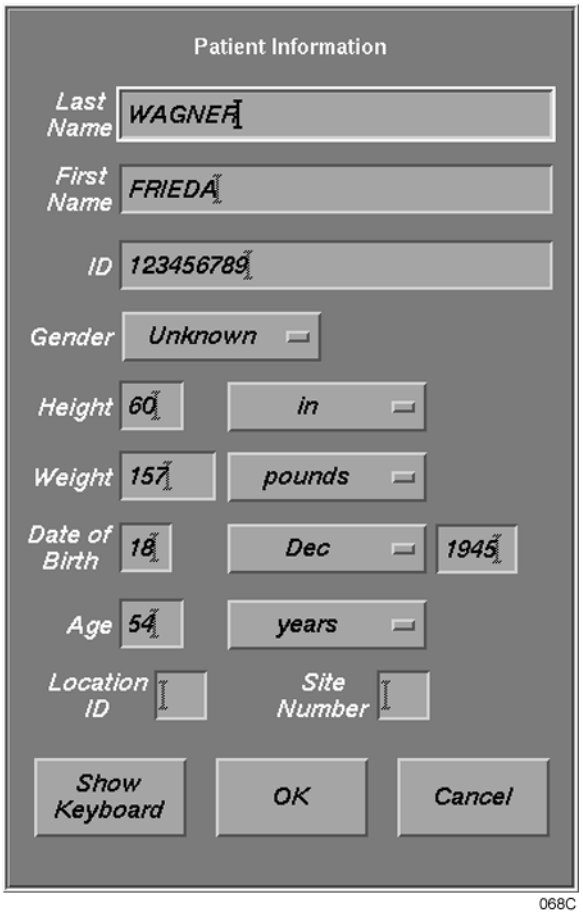
The information shown in each grouping consists of:

- Lead label
- Deviation
- Current complex superimposed over a stored complex, with a vertical line showing the J+ position and a line showing the isoelectric reference point
- A 30-minute trend

For more information on ST analysis, refer to Chapter 9, ECG Monitoring.

Patient Info

Selecting *Patient Info...* from the *Patient Data* popup menu opens the *Patient Information* window on the primary display.



***Patient Information* Window**

The *Patient Information* window allows you to enter demographic patient information that will be used to identify the patient on printed reports, as well as provide information to algorithms and calculations packages.

NOTE: In order for a complete cardiac calculation to be made following a cardiac output trial, the patient's height and weight must be entered before starting the cardiac output trial.

Entering Data

Use the attached keyboard (if available) to enter data, or select *Show Keyboard* to display an on-screen keyboard for entering data.

Last Name

Enter the patient's last name.

First Name

Enter the patient's first name.

Patient ID

Enter the patient's hospital identification number here.

NOTE: The default units for height, weight and age are set in the service mode.

When units of measure are switched, the monitor converts the numbers already entered to the different units of measure.

Height

Choose the appropriate unit of measure (centimeters or inches), and enter the patient's height. The default is centimeters.

Weight

Choose the appropriate unit of measure (kilograms, grams, or pounds), and enter the patient's weight. The default is kilograms.

Date of Birth

Enter the patient's date of birth. When you enter the patient's date of birth, the monitor automatically calculates the age.

Age

Choose the appropriate unit of measure (years, months, or days), and enter the patient's age. The default is years.

Site Number

Enter the number that identifies the site where the data is acquired to the MUSE CV information system.

Location Number

Enter the number that identifies the location of this monitor to a MUSE CV system.

OK

When you select *OK*, the monitor will check your changes to verify that they are within range. If any are out of range, a tone will sound and the cursor will move to the incorrect entry so you can make corrections.

If all entries are within range, the changes will be activated and the patient information window will close.

Cancel

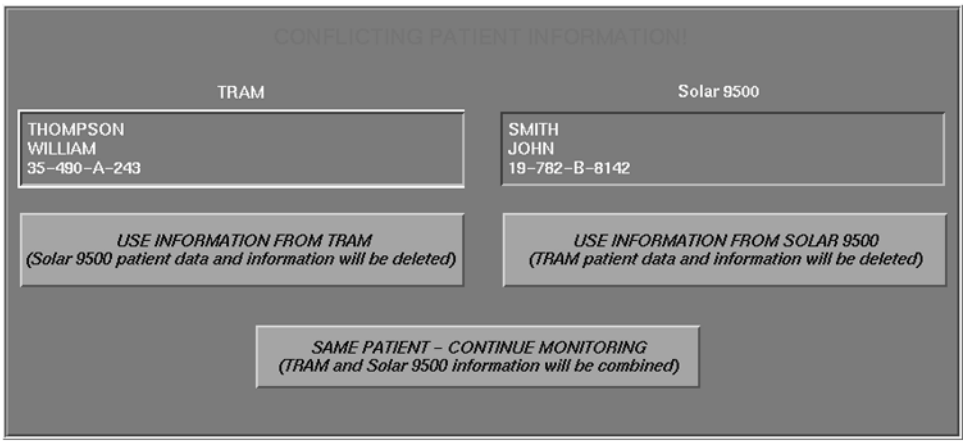
Selecting *Cancel* will close the *Patient Information* window without making changes.

Tram Patient Data

When a Tram module is inserted into the Tram-rac, the Solar 9500 monitor and the Tram module compare the patient identification information (*Last Name*, *First Name*, and *ID*).

- If the Tram and Solar 9500 monitor's patient identification is identical, the patient will be monitored without interruption.
- If the Tram and Solar 9500 monitor's patient identification is conflicting, a window similar to the one shown below appears.

NOTE: Conflicting patient information is defined as any discrepancy in text or ID numerics between the two devices. A patient name or ID left blank is considered in conflict when compared to any text or ID numerics.



Patient Data Conflict Window

You can choose your source of patient data by selecting the *USE INFORMATION FROM TRAM* button or the *USE INFORMATION FROM SOLAR 9500* button.

NOTE: When you select a patient data source (Tram or Solar 9500 monitor), all the patient information and data stored on the other source is deleted.

You can select the *SAME PATIENT - CONTINUE MONITORING* button to continue monitoring. The monitor will compare and synchronize all data when you choose to continue monitoring.

NOTE: The *SAME PATIENT - CONTINUE MONITORING* option is offered as an alternative in the event the user **confirms** that the patient information represents the same patient.

View Other Patient

Selecting *View Other Patient* from the *Patient Data* popup menu opens the *Patient View* window on the primary display. This window is movable.

For more information on viewing another patient, refer to Chapter 7, View Other Patients.

Browser

WARNING
DIAGNOSTIC ACCURACY — When using Browser data for diagnostic purposes, verify that the displayed patient name and ID are valid.

NOTE: *Browser* is a user purchased option.

The *Browser* feature allows access to preconfigured sites on your institution's intranet. All configuration of the browser, including establishing links to sites within your institution's intranet, is performed in the service mode. Refer to the service manual for more information.

Selecting *Browser* from the Patient Data popup menu opens an on-screen, virtual keyboard.

IMG Logon to Windows NT / 2000
User
Administrator
Password:
Domain:
OK
Cancel
Use Tab to Enable Name, Password, Domain
` 1 2 3 4 5 6 7 8 9 0 - = Back
Tab q w e r t y u i o p [ ] \
Caps a s d f g h j k l ; ' Enter
Shift z x c v b n m , . / Shift
206A

Browser Login

Follow these steps to log in to the Browser using the virtual keyboard.

1. Select the *Tab* button to activate the User and Password fields.

   NOTE: You must use the *Tab* button on the virtual keyboard to activate these fields.

2. Enter the user name in the the *User* field.
3. Enter the login password in the *Password* field.

One of two Browser interfaces will appear — a standard Internet Explorer interface or an icon Browser interface. The interface that appears is determined by the settings for the User name in the Weblink MAS system.

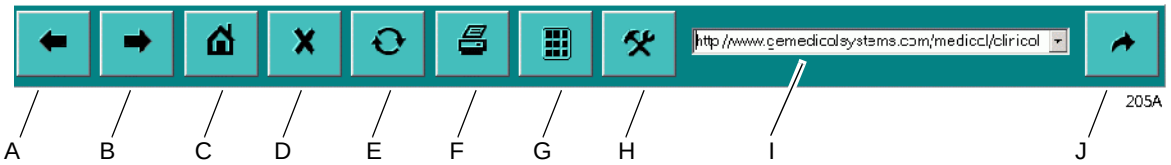
CAUTION
SECURITY — The browser that runs in conjunction with the Solar 9500 information monitor is intended for hospital INTRANET use only. If confidential patient information is made available from the hospital intranet, the security of the data is the responsibility of the hospital.

Internet Explorer Interface

For detailed information regarding Browser operation with this interface, refer to the appropriate Microsoft Internet Explorer version 5.0 or later documentation.

Icon Browser Interface

When the Browser is set to this interface, the menu bar shown below is used to control it. The information that appears in the Browser window beneath the menu bar varies, depending on the website being viewed.

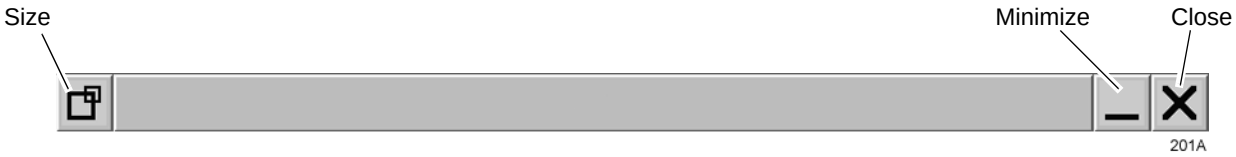


A	Back	Returns to the previous page (only active when more than one page has been viewed).
B	Forward	Moves to the next page (only active when more than one page has been viewed, and the Back button has been used).
C	Home	Returns to the default home page. The home page is set on the Weblink MAS system.
D	Stop	Stops loading of a web page.
E	Refresh	Reloads the current web page.
F	Print	Prints the current web page. **NOTE:** Pages printed from the Browser window print only at the printer connected to the Weblink MAS system. They cannot be printed to a printer controlled by the Solar 9500 monitor (both parallel and network printers).
G	Keyboard	Opens an on-screen virtual keyboard.
H	Tools	Used to configure URLs and set up the default home page.
I	Address field	Shows the web address of the current web page. Clicking on the down arrow at the right of the field opens a popup list of recently viewed pages.
J	Go	After entering a URL in the address field, press this button to go to that web page.

Basic Browser Operations

The basic operations described in this section are applicable to both the Internet Explorer interface and the icon Browser interface.

The illustration below shows the buttons located at the top of the Browser window. The information that appears in the Browser window beneath these buttons will vary depending on the Browser interface being used and the website that is being viewed.



***Browser* Button Bar**

Resizing the Browser

To resize the Browser window, touch or click on the Size icon button in the upper left corner of the browser window. Select the desired size from the popup menu that appears.

NOTE: When resizing, the Browser will restart and you must log in again.

Hiding the Browser

To hide the Browser window, touch or click on the Minimize icon button in the upper right corner of the browser window. The Browser is minimized.

Closing the Browser

To close the Browser, touch or click on the Close icon button.

7 View Other Patients

For your notes

Viewing Other Patients

A feature of the Solar 9500 monitor is the ability to be at one patient's bedside or in the operating room, and use that monitor to view the data from another patient's monitor. The only criteria for this to happen is that the unit and monitor you want to view must be on the same Unity MC network.

NOTE: A monitor is identified by the bed number assigned. Therefore, the terms monitor and bed are used interchangeably.

With network capabilities in place, you can view other patient numerics and waveforms on the monitor in a picture-in-picture format.

IMPORTANT

The View Other Patient feature and data reviewed from a remote location (e.g., central station, alarm display unit, etc.) should not be relied upon for alarm annunciation. These features provide remote viewing capability only.

Guidelines

Here are some guidelines to remember when viewing another patient.

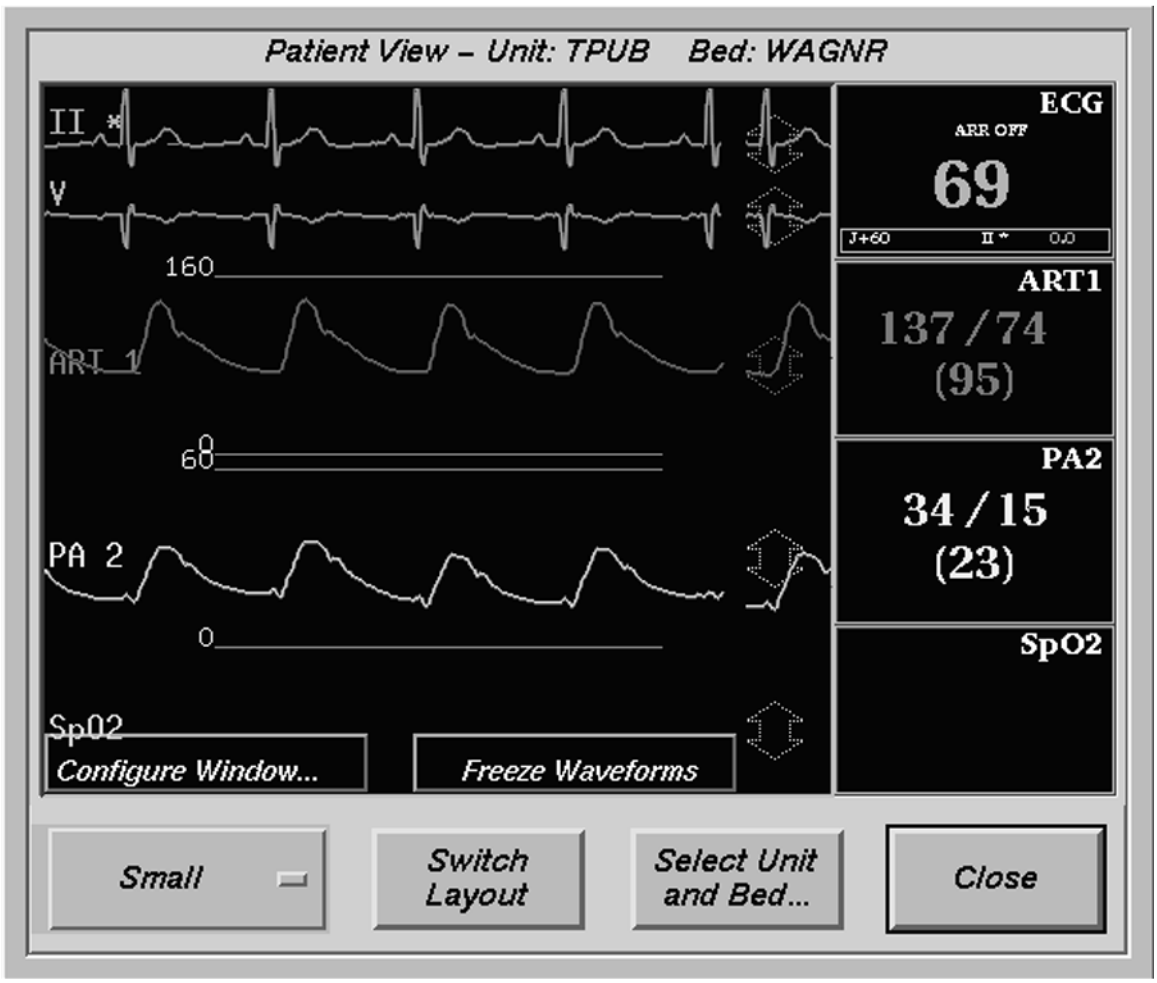
- All monitors must have a bed name and a unit name to be viewed.
- The viewed bed must have active parameter or waveform data acquisition from a Tram module.
- All bedside monitors on the Unity MC network can be viewed by the Solar 9500 Information Monitor, and the Solar 9500 monitor can be viewed by all Unity monitors with "View Other" capability.
- You can view only those parameters that are monitored on the source monitor. For instance, you cannot use the View Other Patient function to monitor a patient's CO2 if that bed is not configured to monitor CO2 (no CO2 module in place).
- ST trends and complexes are not available for viewing.
- The first nine waveforms and all parameters may be viewed.
- The waveforms and parameters viewed are based on the View Other Patient layout selected.
- You have the ability to turn different waveforms on/off or switch the viewed bed layout, but you cannot access parameter control panels for the viewed bed.
- The colors for parameters for the viewed bed are based on the host bed colors when the view is enabled.

Viewed Patient Window

The figure below is an example of a monitor's display when viewing another patient. The monitor you are viewing from is the "host." The *Patient View* window is labeled and color-coded with a gray border to differentiate it from the primary patient's waveform window. Its layout defaults to the display setup layout defined in the service menu for the *Patient View* window.

Other characteristics of the *Patient View* window are:

- The bed number and care unit information are displayed at the top of the window.
- Waveform and parameter color are the default colors of the viewing bed.
- The *Patient View* window may be moved to any position on the display.
- Only one *Patient View* window may be displayed at a a time.
- The receiving bed will show visual alarms and messages for the viewed bed, but audible alarms will not be available.



***Patient View* Window**

Controls

There are controls for setting up the *Patient View* window located along the lower edge of the window.

Window Size

Size options for the *Patient View* window are *Small*, *Medium*, or *Large* (full screen). The default size for the *Patient View* window is *Small*. The default position for the *Patient View* window is the lower right corner of the primary display.

Switch Layout

You can switch the layout for the *Patient View* window. Select *Switch Layout* to open a list of available layouts from which to choose. Highlight your layout choice from the list, and select *OK* to activate your choice, or *Cancel* to close the *Switch Layout* control without making a change.

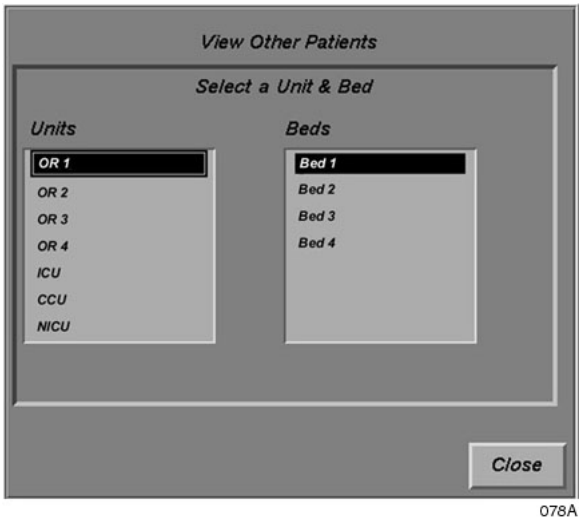
Selecting a Layout for a Patient View Window

When selecting a layout for the *Patient View* window, use the following guidelines.

- Select a layout that contains waveform and parameter windows only.
- Direct action buttons will not be functional. They will be grayed out.
- Scrolling message windows will not display any text.
- Procedure timers will operate but do not have any correlation with the viewed bed.

Select Unit and Bed

To select the bed to be displayed in the *Patient View* window, select *Select Unit and Bed…* to open the *View Other Patients* selection window.



***View Other Patients* Selection Window**

This window contains a list of available units and a list of corresponding beds. By default, the local unit is selected.

Highlight your unit choice from the *Units* list, and all of the viewable beds for that unit are displayed in the *Beds* list. Highlight your bed choice and then select *Close* to close this window and return to the *Patient View* window.

NOTE: Once a bed is viewed, if the window is closed and reopened, the last displayed bed will be viewed.

The lists of available units and beds do not automatically update. To see changes, you must close the window and reopen it.

Close

Select *Close* to close the *Patient View* window.

Configuring Waveforms

Select *Configure Window...* in the waveform area of the *Patient View* window to set up the waveform display. The waveform configuration window opens. This window functions identically for viewed patients as for host patients, with the exceptions that there are no printing configuration controls, and the waveforms available for display are restricted (see criteria below) within the viewed patient's waveform configuration window.

All parameter windows are viewable, but not all waveforms are viewable at the host bed. Up to nine waveforms can be shown, based on the following criteria:

- If available, these four ECG leads will be shown first: I, II, III, and V.
- Next, up to four invasive pressures will be shown.
- Respiration waveforms will be displayed next, until a total of nine waveforms are displayed.
- CO2 waveforms are not available for viewing.

For more information on the *Configure Waveform* window, refer to "Configuring Waveform Windows" in Chapter 1, The Basics.

Freeze Waveforms

The *Freeze Waveforms...* option freezes waveforms in the *Patient View* window. After selected, the label text changes to *Continue.* Select *Continue* to unfreeze waveforms.

CAUTION
The waveforms in the *Patient View* window will not unfreeze upon an alarm condition.

Turn the View Off

The viewed patient data will remain on the screen until turned off (*Close* is selected) or a different patient is selected. All functions are still operational for the host monitor.

8 Maintenance

For your notes

Biocompatibility

When used as intended, the parts of the product described in this operator manual, including accessories that come in contact with the patient during the intended use, fulfill the biocompatibility requirements of the applicable standards. If you have questions about this matter, please contact GE Medical Systems *Information Technologies* or its representatives.

Inspection

An effective maintenance schedule should be established for your monitoring equipment and reusable supplies. This should include inspection as well as general cleaning on a regular basis. The maintenance schedule must comply with the policies of your institution's infection control unit and/or biomed department.

CAUTION
Failure on the part of the responsible hospital or institution employing the use of this monitoring equipment to implement a satisfactory maintenance schedule may cause undue equipment failure and possible health hazards.

Check with your biomedical department to be sure preventive maintenance and calibration has been done. The service manuals contain detailed information.

Follow these guidelines when inspecting the equipment:

- Inspect the equipment for obvious physical damage and replace damaged items.
- Inspect all cords for fraying or other damage. Inspect all plugs and connectors for bent prongs or pins. Repair or replacement must be performed by qualified service personnel.
- Inspect all cable insulation. Qualified service personnel should repair or replace damaged or deteriorated cables.

GE Medical Systems *Information Technologies* service is available 24 hours a day by calling 800-558-7044.

NOTE: Refer to the service manuals for more comprehensive checkout procedures.

General Cleaning

The equipment should be cleaned on a regular basis. (Comply with the policies of your institution's infection control unit and/or biomed department.) The exterior surfaces of the equipment (except the touchscreen) may be cleaned with a dampened, lint-free cloth. Use one of the following approved solutions:

- ammonia (diluted),
- Cidex,
- sodium hypochlorite bleach (diluted), or
- mild soap (diluted).

To avoid damage to the equipment, follow these rules:

CAUTION
Failure to follow these rules may melt, distort, or dull the finish of the case, blur lettering on the labels, or cause equipment failures.

- ALWAYS dilute the solutions according to the manufacturer's suggestions.
- ALWAYS wipe off all the cleaning solution with a dry cloth after cleaning.
- NEVER use wax containing a cleaning substance.
- NEVER pour or spray water or any cleaning solution on the equipment or permit fluids to run behind switches, into the connectors, or into any ventilation openings in the equipment.
- NEVER use these cleaning agents:
  - abrasive cleaners or solvents of any kind,
  - acetone,
  - ketone,
  - alcohol-based cleaning agents, or
  - Betadine.

Cleaning the Touchscreen

NOTE: Turn the display power off before cleaning the touchscreen.

Clean the touchscreen with one of the following approved solutions:

- Household glass cleaner,
- Virex (full strength), or
- Cavicide (diluted: 1/2 oz per gallon of water).

To avoid damage to the equipment, follow these rules:

CAUTION
Failure to follow these rules may melt, distort, or dull the finish of the case, blur lettering on the labels, or cause equipment failures.

- Always dampen the towel and then clean the touchscreen.
- Do NOT spray cleaner directly on the touchscreen.
- Do NOT use these chemicals on the touchscreen:
  - Acetone
  - Methylene chloride
  - Methyl ethyl ketone
  - Hexane
  - Ammonia-based glass cleaners

Cleaning Applied Parts

Cables and Leadwires

CAUTION
Do not use acetone or ketone solvents for cleaning; do not use an autoclave or steam cleaner.

Cables and leadwires can be cleaned with a warm, damp cloth and mild soap, or isopropyl alcohol wipes. Refer to “General Cleaning” earlier in this chapter for safe cleaning techniques.

For more intensive disinfecting (near sterile) Ethylene Oxide (ETO) is acceptable but will reduce the useful lifetime of the cable or leadwire.

CAUTION
The decision to sterilize must be made per your institution's requirements with an awareness of the effect on the integrity of the cable or leadwire.

CO2 Mainstream Sensor

Never immerse the sensor. Clean with a cotton swab dampened with alcohol. Do not autoclave.

CO2 Mainstream Airway Adapter

The Mainstream airway adapter used with the Mainstream module is designed for single patient use only.

Other

For other applied parts such as temperature sensors, catheters, pulse oximetry probes, and NBP cuffs, you must consult the manufacturer for cleaning, sterilization, or disinfecting methods.

Turning Power Off

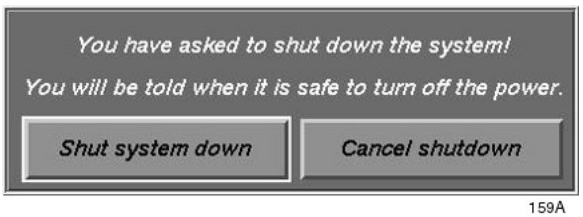
There are two methods of turning power off on the Solar 9500 Information Monitor:

- select the on-screen menu command. This is the preferred method, or
- press the on/off mains power switch located on the back of the processing unit.

CAUTION
Do not move the system while turning power off. Wait 40 seconds after removing power before moving the system.

Using the Menu Command

1. Select *Configuration / Service* from the *Setups* lower control button. The User Configuration window opens.
2. Select *Shut System Down...*
3. Select "*Shut system down*" to begin the orderly shut down process.


You have asked to shut down the system!
You will be told when it is safe to turn off the power.
Shut system down
Cancel shutdown
159A

4. Wait until the message "*Caution: Do not move the Solar 9500 monitor for 40 seconds after turning power off.*" appears, then press the **O** on the on/off power switch on the back of the processing unit.

Using the Power Switch

You can turn off the Solar 9500 monitor with the on/off switch. However, the system sees this as an AC power failure. The monitor will run on the internal battery while it completes an automatic shutdown. A new, fully charged battery only supports 13 continuous shutdowns. It is recommended that you shut down the system using the menu command.

Technical Maintenance

Schematic diagrams, specifications, and other relevant technical information can be found in the service manuals supplied with this equipment. Comply with the policies of your institution's biomedical department or the recommendations made within the Preventive Maintenance section of the product's service manual.

Technical Specifications

Technical specifications are located in the service manual.

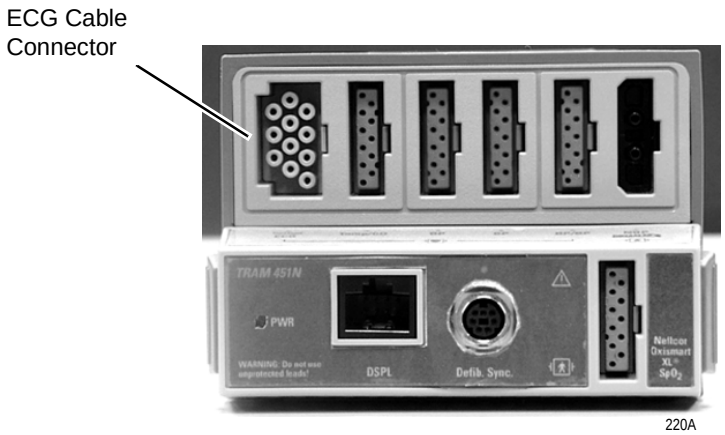
For your notes

9 ECG Monitoring

For your notes

Introduction

ECG monitoring can be done with any of the Tram modules and appropriate cables. This chapter gives guidelines for proper skin preparation, electrode placement, adjusting ECG setup, and problem solving.



Tram Module—ECG Connector

Checklist

1. The Tram module is securely inserted in the Tram-rac housing.
2. Electrodes have been placed on the patient following proper skin preparation.

   NOTE: "When using "snap" leadwires, attach leadwires to electrodes first, then apply electrodes to the patient. This prevents the gel from spreading and becoming ineffective as you attach the snaps to the electrodes.

3. Leadwires are attached to electrodes on the patient.
4. Leadwires are connected to the patient cable and the patient cable is connected to the module.
5. Verify the V-lead label is correct if using a 5-leadwire patient cable. (Refer to this chapter, V Lead Position.)
6. ECG setup is adjusted, if necessary. Follow detailed procedures within this chapter.

Skin Preparation

The quality of ECG information displayed on the monitor is a direct result of the quality of the electrical signal received at the electrode.

Proper skin preparation is necessary for good signal quality at the electrode. A good signal at the electrode provides the module with valid information for processing the ECG data.

Choose flat, non-muscular areas to place electrodes, then follow the established prep protocol for your unit. Following is a suggested guideline for skin preparation:

1. Shave hair from skin at chosen sites.
2. Gently rub skin surface at sites to remove dead skin cells.
3. Thoroughly cleanse the site with a mild soap and water solution. Be sure to remove all oily residue, dead skin cells, and abrasives. Leftover abrasion particles can be a source of noise.
4. Dry the skin completely before applying the electrodes.

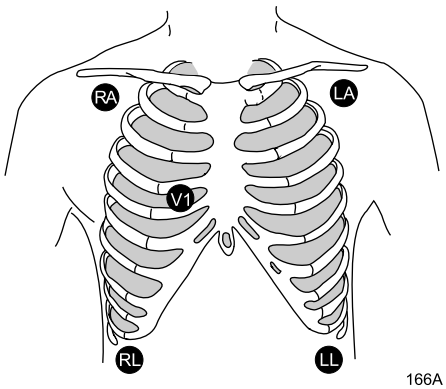
Electrode Placement

The chart below shows the label used to identify each leadwire. Included also is its associated color code per AHA and IEC standards.

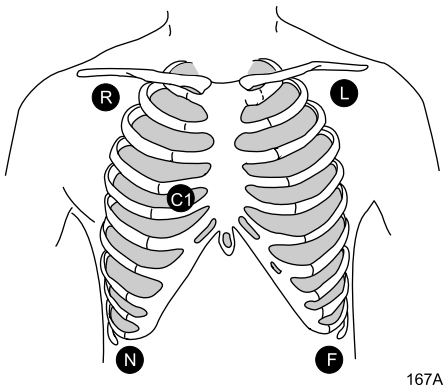
Leadwire	AHA Color	AHA Label	IEC Color	IEC Label
RA (right arm)	white	RA	red	R
LA (left arm)	black	LA	yellow	L
RL (right leg)	green	RL	black	N
LL (left leg)	red	LL	green	F
V1 (precordial)	brown	V1	white	C1
V2 (precordial)	yellow	V2	yellow	C2
V3 (precordial)	green	V3	green	C3
V4 (precordial)	blue	V4	brown	C4
V5 (precordial)	orange	V5	black	C5
V6 (precordial	purple	V6	purple	C6

5-Leadwire Electrode Placement

Following is a suggested configuration when using five leadwires:



AHA Configuration



IEC Configuration

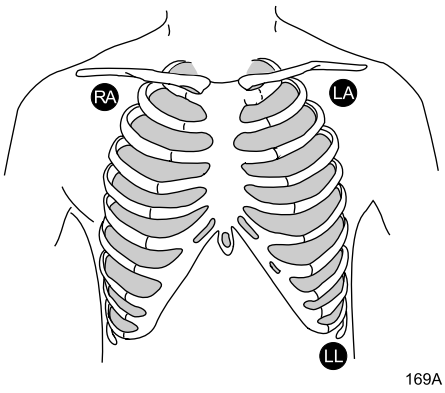
Right arm (RA) and left arm (LA) electrodes should be placed just below the right and left clavicle.

Right leg (RL) and left leg (LL) electrodes should be placed on a non-muscular surface on the lower edge of the rib cage.

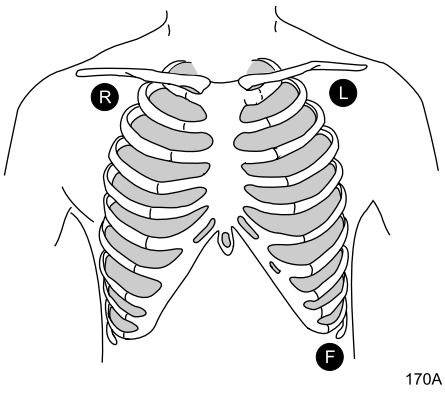
The chest (V) electrode should be placed according to the physician's preference.

Alternate 3-Leadwire Electrode Configuration

When a 5-leadwire electrode configuration is not desirable, a 3-leadwire electrode configuration can be used.



AHA Configuration



IEC Configuration

Standard 3-Leadwire Cable

NOTE: Electrode configuration will vary depending on the type of patient cable you are using. Refer to "Three-Leadwire Configuration" below.

Right arm and left arm electrodes should be placed just below the right and left clavicle.

Left leg electrode should be placed on a non-muscular surface on the lower edge of the rib cage.

Three-Leadwire Configuration

Standard 3-leadwire Cable (Rotating Reference)

- Selectable lead I, II, or III cable with a rotating reference (RA, LA, LL).

Operation of the monitor with this standard cable allows you to select one of three leads (I, II, or III) for monitoring.

When using the standard, 3-leadwire cable with a compatible module, the following operating conditions occur:

- Lead analysis automatically switches to single lead analysis.
- Display lead choices are limited to I, II, and III.
- Any options usually allowing more than one ECG selection will be disallowed.
- Unlike the fixed reference 3-leadwire cables (see next section), respiration can be monitored from either lead I or II. It is not dependent on the displayed lead.

Fixed RL Reference Cables

There is also an older style of 3-leadwire patient cables with a fixed right leg reference:

- Lead I cable with a fixed right leg reference (right arm, left arm, left leg). Respiration is monitored from lead I only.
- Lead II cable with a fixed left arm reference (right arm, left leg, left arm). Respiration is monitored from lead II only.

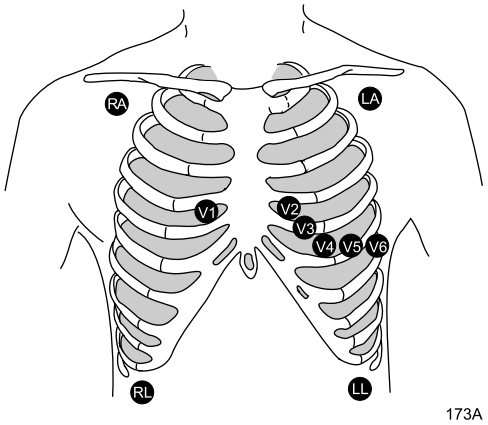
Operation of the monitor with a fixed RL reference is limited to the fixed lead designated. If using a Lead I cable, respiration is monitored from Lead I, etc. Multi-lead analysis defaults on. Change lead analysis to single lead analysis with a fixed RL reference cable.

10-Leadwire Electrode Placement

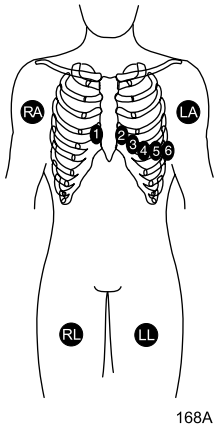
WARNING
To assure accurate 12-lead analysis when using a 10-leadwire patient cable, you must verify that the correct leadwire block is plugged into the appropriate side of the cable. The V2 through V6 leadwire block is color coded brown.

Following is a suggested electrode configuration for traditional monitoring, and an alternate, traditional, cardiology configuration.

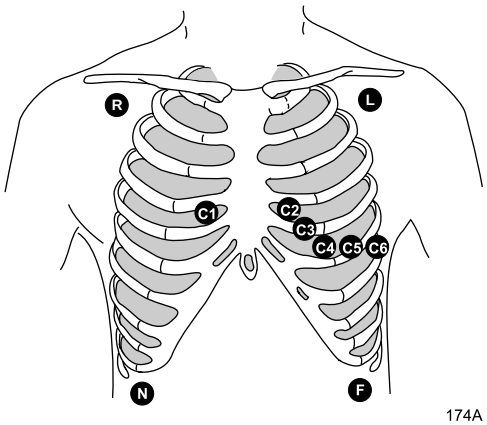
NOTE: For the most accurate serial comparisons, use the same electrode configuration as used on prior analyses for the patient.



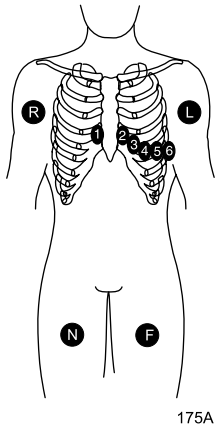
Traditional Monitoring AHA Electrode Configuration



Traditional Cardiology AHA Electrode Configuration



Traditional Monitoring IEC Electrode Configuration



Traditional Cardiology IEC Electrode Configuration

For traditional monitoring, right arm and left arm electrodes should be placed just below the right and left clavicles. For traditional cardiology (resting ECG), place them on the arms, off the torso.

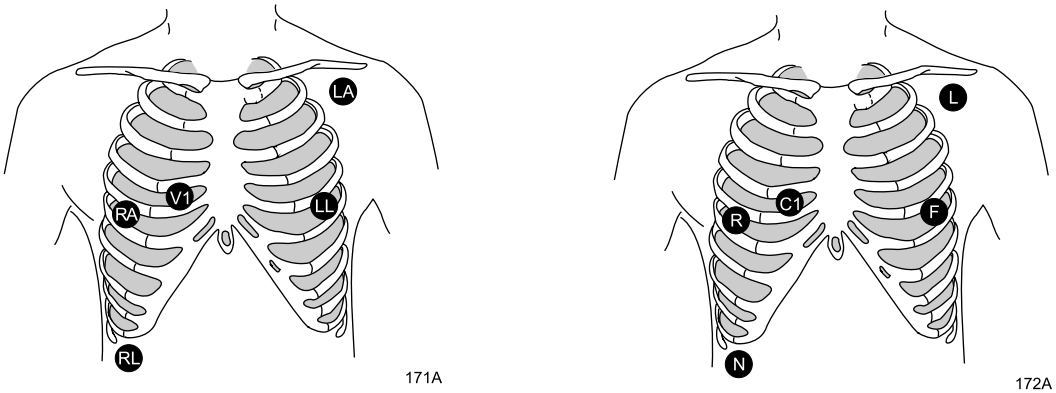
For traditional monitoring, right leg and left leg electrodes should be placed on a flat non-muscular surface below the rib cage. For traditional cardiology (resting ECG), place them below the level of the umbilicus.

The six chest electrodes should be placed as indicated below:

1. Fourth intercostal space at the right border of the sternum.
2. Fourth intercostal space at the left border of the sternum.
3. Midway between locations 2 and 4.
4. At the mid-clavicular line in the fifth intercostal space.
5. At the anterior axillary line on the same horizontal level as 4.
6. At the mid-axillary line on the same horizontal level as 4 and 5.

Electrode Placement for Pacemaker Patients

Electrodes need to be repositioned to modify detection of the electrical signals generated by the pacemaker. Following is a suggested configuration:



AHA Configuration **IEC Configuration**

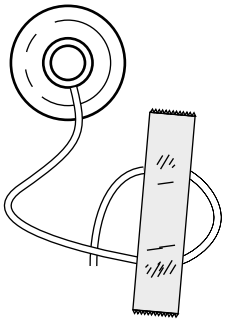
Electrode Placement for Pacemaker Patients

When using this configuration, display Lead II as your primary ECG lead.

The right arm (RA) electrode is moved down to the fifth intercostal space, and the left leg (LL) electrode is moved up to the fifth intercostal space.

NOTE: After all electrodes are in place, ensure minimum of 0.5 mV of signal is present on each lead (I, II, III, V).

Maintaining Quality ECG Signal


176A

Regardless of patient age, electrodes should be replaced at least every 48 hours to maintain quality signals during long-term monitoring. Over the course of 48 hours, the electrode gel will start to dry out and the adhesive will age. After a long period of time, the patient's sensitive skin also may be irritated by the gel or adhesive, causing discomfort.

Stabilize the electrode and leadwire with a leadwire stress loop near the electrode. Tape the stress loop to the patient. A secured stress loop prevents leadwire rotation about the electrode snap, leadwire tugging at the electrode, and ECG artifact.

Surgical Considerations for Electrode Placement (Adults)

Thorough skin preparation is very important to help keep electrosurgical cautery unit interference to a minimum. Do a thorough skin prep to the skin next to the grounding pad as well.

Electrode placement during surgery is dependent on the type of surgery being performed. For example, with open heart surgery, the RA and LA electrodes might be placed on the right and left shoulders. The chest lead (V) would be on the left side at mid-chest.

Place the right leg electrode close to the ESU grounding pad.

Electrosurgical Unit (ESU) ECG Filter

The Multi-Link ESU ECG patient cable is recommended when using the monitor in the presence of an electrosurgical unit. This cable, with a built-in ESU filter, helps reduce electrosurgical noise detected on the ECG signal.

ECG Artifact

Arrhythmia processing is suspended during an "*Artifact*" condition. Should the artifact condition persist for 20 seconds out of 30 seconds, an audible system warning (repetitive foghorn) will sound and the message "*Artifact*" will be displayed in the top waveform window until the condition is resolved.

ECG Monitoring Information

The ECG information is acquired by the Tram module. The monitor provides controls to invoke the following programs and messages from the Tram module:

- Pace detection
- Arrhythmia
- Single vs. Multi Lead Analysis
- Relearn ECG
- ST segment analysis
- Filter selection

Pace Detection

Be aware of the following when monitoring a patient with a pacemaker.

WARNINGS

FALSE CALLS—False low heart rate indicators or false asystole calls may result with certain pacemakers because of electrical overshoots.

MONITORING PACEMAKER PATIENTS—Monitoring of pacemaker patients can only occur with the pace program activated.

PACEMAKER SPIKE—An artificial pacemaker spike is displayed in place of the actual pacemaker spike. All pacemaker spikes appear uniform. Do not diagnostically interpret pacemaker spike size and shape.

PATIENT HAZARD — A pacemaker pulse can be counted as a QRS during asystole in either pace mode. Keep pacemaker patients under close observation.

RATE METERS—Keep pacemaker patients under close observation. Rate meters may continue to count the pacemaker rate during cardiac arrest and some arrhythmias. Therefore, do not rely entirely on rate meter alarms.

SURVEILLANCE — Maintain close surveillance of pacemaker patients. Heart rate errors can occur.

CAUTION

FDA POSTMARKET SAFETY ALERT — The United States FDA Center for Devices and Radiological Health issued a safety bulletin October 14, 1998. This bulletin states “that minute ventilation rate-adaptive implantable pacemakers can occasionally interact with certain cardiac monitoring and diagnostic equipment, causing the pacemakers to pace at their maximum programmed rate.

The FDA further recommends precautions to take into consideration for patients with these types of pacemakers. These precautions include disabling the rate responsive mode and enabling an alternate pace mode. For more information, contact:

Office of Surveillance and Biometrics, CDRH, FDA
1350 Piccard Drive, Mail Stop HFZ-510
Rockville, MD 20850
U.S.A.

Monitoring Pacemaker Patients

There are two pacemaker processing modes, *Pace 1* and *Pace 2*. The *Pace 1* and *Pace 2* modes use different algorithms for pacemaker artifact rejection. The clinician must be the judge as to which mode is better for each patient.

NOTE: The *Off* option turns pacemaker detection off. It does NOT perform pacemaker detection. It should NOT be used for patients with pacemakers.

The *Pace 1* mode allows successful detection of the largest variety of paced QRS morphologies. As a direct consequence, this mode does have a higher risk of counting pacemaker artifact as QRS complexes during *ASYSTOLE*. For this reason, it is imperative that the user keep patients with pacemakers under close observation. It is also recommended that the user set the low heart rate limit on the monitor close to the minimum pacing rate, and that the *BRADY* arrhythmia alarm level be elevated to a Warning or Crisis level.

The *Pace 2* mode is much more conservative in recognizing paced QRS morphologies and is recommended for use whenever possible. It is designed to minimize the possibility of counting pacemaker artifact as QRS complexes during *ASYSTOLE*. If the monitor does not adequately detect paced beats in the *Pace 2* mode, then the user may wish to try the *Pace 1* mode.

NOTE: Please observe all cautions as described when choosing the *Pace 1* mode of operation.

When either pace mode is enabled, the software places an artificial spike on the waveform whenever the pacemaker triggers. The monitor shows the pulse on the ECG waveform where the pacer spike is detected. The pacer spike appears on the ECG waveform. A *P* label in the ECG parameter window is shown when the Pacer program is enabled. The default condition for the Pacer program is *Off*.

NOTE: Moderate and maximum ECG filtering is not recommended with pacemaker patients. (Refer to this chapter, Filtering.)

When pace detection is enabled, the monitor's algorithm uses the lead which is designated with the asterisk (*) for pace detection.

Additional Suggestions

For successful monitoring of pacemaker patients follow these suggestions:

- Use recommended electrode placement. (Refer to the Electrode Placement section in this chapter.)
- Brady, Pause, and Low Heart Rate are additional alarms available for use when monitoring pacemaker patients.
- Problems you may experience are:
  - heart rate double counting;
  - inaccurate alarms for low heart rate or asystole;
  - pacemaker spikes not recognized by the software.
- Possible solutions to above problems are:
  - relearn arrhythmia;
  - try an alternate electrode placement;
  - try single-lead analysis;
  - try switching to the other pace detection mode.
- Pacemaker mode:
  In most cases, *Pace 2* mode will effectively monitor a pacemaker patient. However, if you are experiencing problems, select the *Pace 1* mode as an option, and observe all cautions as described for the *Pace 1* mode of operation.

For more information refer to Pacemaker Troubleshooting in this chapter.

Arrhythmia

WARNINGS

VENTRICULAR ARRHYTHMIAS—The GE Medical Systems *Information Technologies* arrhythmia analysis program is intended to detect ventricular arrhythmias. It is not designed to detect atrial or supra-ventricular arrhythmias. Occasionally it may incorrectly identify the presence or absence of an arrhythmia. Therefore, a physician must analyze the arrhythmia information in conjunction with other clinical findings.

SUSPENDED ANALYSIS—Certain conditions suspend arrhythmia analysis. When suspended, arrhythmia conditions are not detected and alarms associated with arrhythmias do not occur. The messages which alert you to the conditions causing suspended arrhythmia analysis are: Leads Fail and Artifact.

GE Medical Systems *Information Technologies*' EK-Pro algorithm simultaneously uses leads I, II, III, and the V lead identified in the ST menu for ECG and arrhythmia analysis.

Lethal

Lethal arrhythmias are Asystole, VFib/VTac, and V Tach. (Refer to this chapter, Arrhythmia Conditions, for arrhythmia definitions.)

The monitor shows any arrhythmia messages above the top ECG waveform. The default condition for the Arrhythmia program is *Off*.

Full

Full arrhythmia analysis expands the number of arrhythmias detected. Full arrhythmia analysis includes a PVC per minute alarm. The number of PVCs detected over the last minute is displayed in the ECG parameter window.

Arrhythmia Conditions

Following is an alphabetical list of the full and lethal arrhythmia messages which will be displayed when arrhythmia is on and the condition occurs. A definition of each arrhythmia condition is included. How the monitor responds to each condition is determined by the alarm level to which the arrhythmia has been assigned. Refer to Chapter 4, Alarms and Limits, to view the alarm level settings for arrhythmias.

ACC VENT

Adult—Accelerated ventricular occurs when six or more ventricular beats are detected with an average heart rate for the ventricular beat between 50 and 100 beats per minute.

0-2 years—Occurs when six or more ventricular beats are detected with an average heart rate for the ventricular beat between 60 and 160 beats per minute.

3-10 years—Occurs when six or more ventricular beats are detected with an average heart rate for the ventricular beat between 60 and 140 beats per minute.

11-13 years—Occurs when six or more ventricular beats are detected with an average heart rate for the ventricular beat between 60 and 130 beats per minute.

ASYSTOLE

Ventricular asystole occurs whenever the displayed heart rate drops to zero.

BIGEMINY

Occurs when two or more bigeminal cycles (a ventricular beat followed by a non-ventricular beat) are detected.

BRADY

Bradycardia is the average of the most recent eight R-to-R intervals at a heart rate less than the set low heart rate limit.

NOTE: The Brady limit matches the low heart rate limit. If the low heart rate limit is changed, the Brady limit changes.

COUPLET

Occurs when two ventricular beats are detected and have non-ventricular beats before and after the couplet. The coupling interval must be less than 600 milliseconds.

IRREGULAR

Occurs when six consecutive normal R-to-R intervals vary by 100 milliseconds or more.

PAUSE

Occurs when the interval between two consecutive beats exceeds three seconds.

PVC
Isolated premature ventricular complexes occur when a premature ventricular beat is detected and has non-ventricular beats before and after.

R ON T
Occurs when a ventricular complex is detected within the repolarization period of a non-ventricular beat.

TACHY
Tachycardia is four R-to-R intervals at a heart rate greater than the set high heart rate limit.

NOTE: The Tachy limit matches the high heart rate limit. If the high heart rate limit is changed, the Tachy limit changes.

TRIGEMINY
Occurs when two or more trigeminal cycles (a ventricular beat followed by two non-ventricular beats) are detected.

V BRADY
Adult—Ventricular bradycardia occurs when a run of three or more ventricular beats is detected with an average heart rate that is less than or equal to 50 beats per minute.

0-2, 3-10, and 11-13 years—Occurs when a run of three or more ventricular beats is detected with an average heart rate that is less than or equal to 60 beats per minute.

VFIB/VTAC
Ventricular fibrillation occurs when the ECG waveform indicates a chaotic ventricular rhythm.

V TACH
Adult—Ventricular tachycardia occurs when a run of six or more ventricular beats is detected with an average heart rate greater than or equal to 100 beats per minute.

0-2 years—Occurs when a run of six or more ventricular beats is detected with an average heart rate greater than or equal to 160 beats per minute.

3-10 years—Occurs when a run of six or more ventricular beats is detected with an average heart rate greater than or equal to 140 beats per minute.

11-13 years—Occurs when a run of six or more ventricular beats is detected with an average heart rate greater than or equal to 130 beats per minute.

VT > 2

Adult—Ventricular tachycardia > 2 occurs when a run of ventricular beats is detected with a duration of less than six beats but longer than two beats, and with an average heart rate that is greater than or equal to 100 beats per minute.

0-2 years—Occurs when a run of ventricular beats is detected with a duration of less than six beats but longer than two beats, and with an average heart rate that is greater than or equal to 160 beats per minute.

3-10 years—Occurs when a run of ventricular beats is detected with a duration of less than six beats but longer than two beats, and with an average heart rate that is greater than or equal to 140 beats per minute.

11-13 years—Occurs when a run of ventricular beats is detected with a duration of less than six beats but longer than two beats, and with an average heart rate that is greater than or equal to 130 beats per minute.

Single vs. Multi-Lead Analysis

With the Lead Analysis option, you can choose single lead analysis or multi-lead analysis for ECG and arrhythmia analysis.

Multi-Lead Analysis

Multi-lead analysis examines ECG leads I, II, III, and the V lead, whether they are displayed or not, to help eliminate false alarms and improve the capability of the system to:

- detect beats which occur isoelectric to a single chest lead;
- discriminate artifact that appears in one lead compared to the other lead vectors;
- provide a “smart-lead fail” feature where the failed lead is identified and, if available, another lead is provided for display;
- continue arrhythmia processing even after a lead change.

Single Lead Analysis

Single lead analysis uses only the lead designated with the asterisk (*) and as identified in the ECG Controls window to process ECG and arrhythmia information.

When monitoring an adult, single lead analysis would be beneficial when:

- using an external, temporary pacemaker with a Zoll interface cable;
- using the GE Medical Systems *Information Technologies* telemetry module;
- troubleshooting pacemaker detection and/or arrhythmia detection.

NOTE: ECG is automatically relearned whenever lead analysis is switched from multi-lead to single-lead.

It is not automatically relearned whenever lead analysis is switched from single-lead to multi-lead.

Relearn ECG

During monitoring of ECG, it may be necessary to use the *Relearn* option when a dramatic change in the patient's ECG pattern has occurred. A change in the ECG pattern would result in:

- incorrect arrhythmia calls,
- incorrect ST measurements, and/or
- inaccurate heart rate.

The *Relearn* option will allow the monitor to learn the new ECG pattern to correct arrhythmia calls and heart rate value, and restore ST measurements.

Select *Relearn* option from the *ECG Controls* window. This is a direct action option.

During the learning process, dashes (––) replace the heart rate value in the ECG parameter window.

Smart-Lead Fail

NOTE: The smart-lead fail feature works only when using a 5-leadwire or 10-leadwire electrode configuration.

The smart-lead fail feature is continually checking the integrity of the electrodes to allow uninterrupted monitoring. If the quality of an electrode signal degrades to an inadequate level, a lead fail message will be displayed. If the lead fail affects the ECG waveform monitored in the top trace position on the screen, monitoring will automatically switch to another lead. Refer to the chart below.

Message	New lead monitored
RA Fail	Lead III
LL Fail	Lead I
LA Fail	Lead II
V Fail	Lead II
Leads Failed	No waveforms displayed—RL fail or multiple leads fail

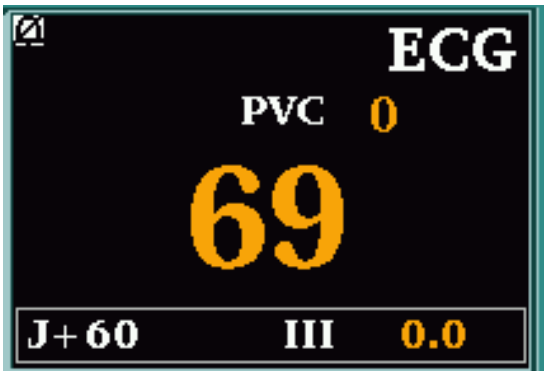
NOTE: Leads V2-V6 cannot be set as primary leads. While one of these could be physically positioned in the top trace, it would not be tagged by the monitor as the primary ECG lead.

If you are using a 10-leadwire electrode configuration, you have the additional V2-V6 leads. If one of these V leads fails while it is displayed in the top trace position, monitoring will switch to Lead II. To clear a lead-fail message for V2-V6, select the *Clear V2-V6 Fail* button in the *ECG Controls* window.

Some other considerations about the smart-lead fail feature as it relates to the Solar 9500 monitor are listed below:

- If a lead is active, and then goes into a lead-fail condition, a lead fail message will be displayed.
- If a lead is not active, no lead-fail message will be displayed.
- Discharging the patient will reset the smart-lead fail feature.

ECG Parameter Window



ECG Parameter Window

ECG Waveform Display

Configuration

The waveforms for ECG in the waveform configuration window are accessed by selecting the *Configure Window...* button in the waveform window. For more information on configuring waveforms, refer to "Configuring Waveform Windows" in Chapter 1, The Basics.

ECG Leads

All available ECG leads can be displayed as waveforms, as can all available ST leads. To mark an ECG lead for display in the waveform window, select its corresponding button so the indicator light is on. To turn the waveform off for an ECG lead, select its corresponding button so the indicator light is off.

NOTE: The use of a 3-leadwire, 5-leadwire, or 10-leadwire cable will be reflected by the choices in the waveform configuration window.

The only valid V lead with a 12-lead configuration for ST segment monitoring, arrhythmia analysis, single lead/primary lead monitoring, and balloon pump analog output is V1.

NOTE: Waveforms can be moved using their handles (shown below) on the right edge of the waveform window.

The ECG lead selected in the *ECG Lead and Size* control in the *ECG Controls* window will be in the topmost (primary lead) position on the waveform display, and will have an asterisk (*) by its lead label if the selected size is 1. If the selected size is not 1, then the size setting (e.g., x2) will be next to the lead label in the waveform window. This primary lead will also be indicated in the ECG parameter window (see figure above).

If the waveform for this primary lead is moved to a position lower than another ECG waveform, then it is no longer marked as the primary lead; the new topmost lead is then considered to be the primary lead. This change is reflected in the ECG window and the ECG parameter window.

ST Leads

To mark an ST lead for display in the waveform window, select the *ST Leads...* option in the waveform configuration window. The *Select ST Leads For Display* window opens. To mark an ST lead for display in the waveform window, select its corresponding button so the indicator light is on. ST information is displayed in the waveform window as ECG complexes with accompanying 30-minute trends.

To turn the waveform display off for an ST lead, select its corresponding button so the indicator light is off. For more information on ST waveform display, refer to "ST Waveform Information" later in this chapter.

Synchronized Cardioversion

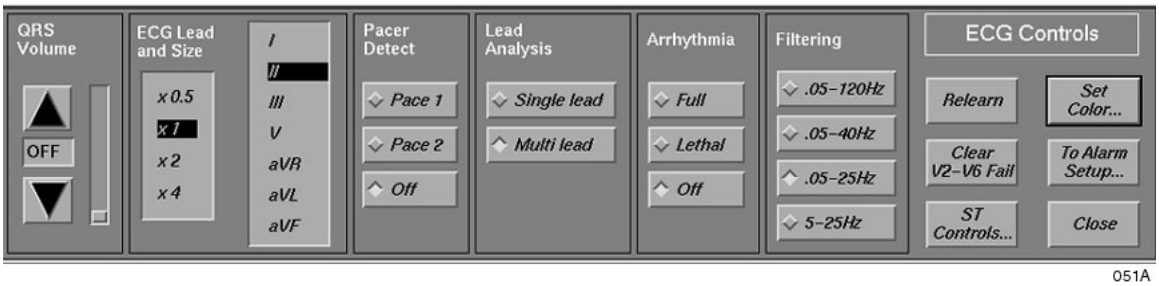
The lead displayed in the top trace position of the waveform window is the signal output to the **DEFIB SYNC** connector on the front of the Tram module. The software provides a defib sync pulse for digital synchronization and places a sync return marker on the ECG waveform.

NOTE: The sync return marker is placed on the waveform only when a device provides a sync return to the Tram module.

If the defibrillator is to be synchronized with the analog ECG signal, review the patient's ECG leads and place the one with the greatest amplitude in the top position on the monitor.

ECG Controls Window

To access the *ECG Controls* window, touch or click the cursor in the ECG parameter window or select *ECG...* from the *ECG* lower control button. After adjusting the ECG controls, select *Close* to exit this window.



***ECG Controls* Window**

QRS Volume

Possible QRS volume levels range from *10* (loudest) to *Off*. To adjust the QRS volume level, use the up and down arrows to change the volume indicator number.

ECG Lead and Size

These choice lists control the primary displayed ECG lead and the ECG waveform size. To make a selection, highlight your choice from the list of options.

ECG Lead

This option enables you to change the lead currently displayed as the primary lead—the one marked with the asterisk (*). This option is useful when you are selecting a lead for pacemaker detection or analog output.

NOTE: There will only be one V lead choice even if you are using a 10-leadwire cable (labeled V1). The V lead available is determined by the V lead identified in the ST Controls window.

If you are using a standard (selectable lead), three-leadwire patient cable, the list only has leads I, II, and III as available choices.

ECG Size

The Size option enables you to change the size of all the ECG waveforms displayed on the screen. This may be necessary when diagnosing or problem solving. Normal size (x 1) is recommended unless circumstances require otherwise.

Selections are *x 0.5*, *x 1*, *x 2*, and *x 4* for display and printing.

NOTE: If a size other than x 1 is used, the size is displayed on the left side of the screen next to the ECG waveform.

Size x 2 and greater will lower the QRS detection threshold. This may be helpful for low amplitude QRS waveforms. Use with caution since baseline artifact may be detected as a QRS. Waveforms are graphed the same size as displayed. ST complexes are displayed based on the ECG size selected and always print at that size.

Pacer Detect

The *Pacer Detect* option enables/disables the pacemaker detection program. It must be used whenever the monitored patient has a pacemaker. Pacer detection choices are *Pace 1*, *Pace 2*, and *Off*. The default selection for pacer detection is *Off*.

NOTE: The *Off* option turns pacemaker detection off. It does NOT perform pacemaker detection. Either the *Pace 2* or *Pace 1* option MUST be used with patients who have pacemakers.

NOTE: Be aware that a pacemaker pulse could be falsely counted as a QRS during asystole in either pace mode.

For more information on monitoring pacemaker patients, refer to “Pace Detection” earlier in this chapter.

Lead Analysis

The *Lead Analysis* controls signal the Tram module to process the ECG in *Single Lead* or *Multi Lead* mode. The default selection is *Multi Lead* mode.

In *Single Lead* mode, only the top ECG lead will process ECG and arrhythmia information.

Arrhythmia

The arrhythmia control signals the monitor to ignore or accept arrhythmia calls from the Tram module. Choices are *Full*, *Lethal* or *Off*. The default selection for arrhythmia is *Off*.

NOTE: An “*ARR OFF*” message appears in the ECG parameter box when you select *Off*.

Filtering

The filtering option offers four choices for filtering the ECG waveform data on the display and graph strip.

NOTE: Filters affect displayed and printed ECG waveform only. ST analysis and arrhythmia analysis are not affected by filter choice.

Choices are as follows:

.05–120Hz—the diagnostic filter, provides the least amount of filtering.

.05–40Hz—the monitoring filter, is recommended for typical monitoring applications.

.05–25Hz—the moderate filter, is used to reduce high frequency interference, i.e., ESU.

NOTE: This filtering choice is not recommended for pacemaker patients.

5–25Hz—the maximum filter, provides maximum filtering, and is used to stabilize the ECG baseline.

NOTE: This filtering choice is not recommended for pacemaker patients.

The default selection for filtering is *.05–25Hz*.

WARNING
The *5–25Hz* filter alters displayed ECG morphology. Do not rely on ECG morphology for diagnostic purposes when this filter is selected. When selected, "*5Hz*" is displayed in the ECG parameter window, and it appears in the graph header.

ECG Controls

The ECG controls also offer buttons which open/activate other related areas/functions. These buttons are:

Relearn—relearns the patient's QRS pattern to enable more accurate monitoring.

Clear V2–V6 Fail—clears the *V2–V6 Fail* message when switching from a 10-leadwire cable to a 5-leadwire cable.

ST Controls...

Set Color...

To Alarm Setup...

Close

ST Analysis

ST Numerics

The GE Medical Systems *Information Technologies* ST analysis program is performed on multiple leads simultaneously. It identifies the ST segment of the QRS complex as beginning at the J-point and ending 60 milliseconds following the J-point for adult patients (refer to the following page for the J+ default values for other ages). The displayed ST numerics indicate either a positive or negative elevation in relation to the isoelectric reference point (I) which is also determined by the program.

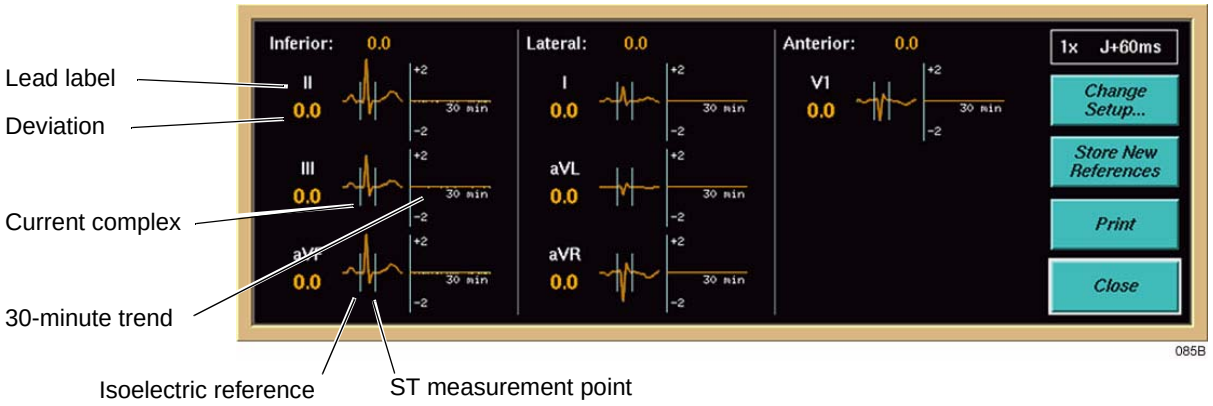
ST information is acquired by the Tram module. Alarm limits for the ST segment lead groups can be set via the *Alarm Setup...* screen.

ST Waveform Information

ST information can also be displayed in the waveform window, as ECG complexes with accompanying 30-minute trends. Each complex and trend pair is marked with the appropriate lead label and scaling information. There are controls for adjusting the format of the ST information displayed in the waveform window. Refer to the ST Controls Window section of this chapter for more information.

ST Analysis Window

To access the ST Analysis window, select *ST Analysis* from the *Patient Data* or *ECG* lower control popup menu.



ST Analysis Window

This window displays the seven leads of ST information, grouped according to their lead groups. The ST measurement point varies depending on patient age. The J+ default values are as follows:

0 – 2 years: J+ 33 ms

3 – 8 years: J+ 42 ms

9 – 13 years: J+ 50 ms

(> 13 years) Adult: J+ 60 ms

The information shown in each grouping consists of:

- Lead label
- Deviation
- Current complex superimposed over a stored complex, with a vertical line showing the ST measurement point and a line showing the isoelectric reference point
- A 30-minute trend

Alarm Condition

In the event any lead within a group exceeds the alarm limit for that group, the group value displays in reverse video.

NOTE: The color used for the alarm condition reverse video depends on the alarm level. Refer to Chapter 4, Alarms and Limits, for more information.

Change Setup…

Selecting *Change Setup…* changes the ST analysis setup. Refer to the ST Control Window section later in this chapter.

Store New References

Stores the current template as the reference template.

Print

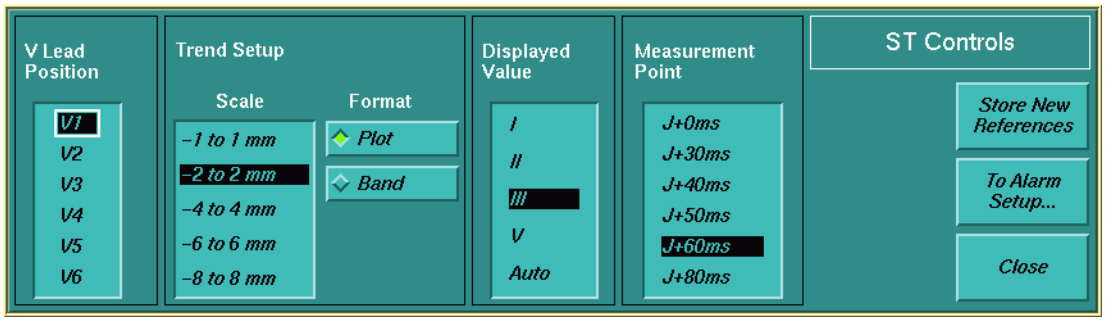
Select *Print* to print the ST analysis information currently displayed in the ST Analysis window.

Close

To close the ST Analysis window, select *Close*.

ST Controls Window

To access the *ST Controls* window, select *ST...* from the ECG lower control popup menu, select *ST Controls* from within the *ECG Control* window, or use the *Change Setup...* button in the *ST Analysis* window. After adjusting the ST controls, select *Close* to exit this window.



***ST Controls* Window**

V Lead Position

This choice list allows you to label the V lead position when using a 5-leadwire cable. When using a 10-leadwire cable, only V1 is available for ST analysis.

V Lead Position Option with a 5-Leadwire Cable

With a standard, 5-leadwire patient cable, this choice list labels the V lead as placed in your electrode configuration. This V lead is used in ST analysis as well as arrhythmia analysis. With a 5-leadwire cable you only connect one V lead, therefore, you must place the electrode in the V position you want and then be certain the label matches the position. GE Medical Systems *Information Technologies* defaults this label as V1, but you can change it.

To make a selection, highlight your choice from the list of options.

V Lead Position Option with a 10-Leadwire Cable

With a 10-leadwire patient cable with all V leads attached to the patient, ST measurements are performed on V1. The Solar 9500 monitor defaults the *V Lead Position* option to V1 when a 10-leadwire cable is used, and the choice list header is grayed out, indicating that this option is not selectable.

Trend Setup Scale

The Trend Setup Scale control lists alternative scale choices for the ST trends displayed in ST analysis window and in the waveform window. Choices are *–1 to 1 mm*, *–2 to 2 mm*, *–4 to 4 mm*, *–6 to 6 mm*, and *–8 to 8 mm*. The default setting *is –2 to 2 mm*.

To make a selection, highlight your choice from the list of options.

Trend Setup Format

Trend Setup Format control options are *Plot* or *Band*.

Plot displays a two-dimensional graph of the ST information, while *Band* displays a color coded trend of ST information. The selected choice is reflected in the ST analysis window.

NOTE: When printing, the plot format is always used.

Displayed Value

The *Displayed Value* control determines which ST lead will be displayed in the ECG parameter block. Choices are *I*, *II*, *III*, *V* or *Auto*. When *Auto* is selected, the ST lead with the greatest absolute deviation is displayed. Additionally, the lead is tagged with an asterisk in the parameter window to indicate that Auto mode is selected.

Measurement Point

The *Measurement Point* control lists alternative choices for the J-point position displayed in ST analysis window and in the waveform window. Choices are *J+0ms*, *J+30ms*, *J+40ms*, *J+50ms*, *J+60ms*, and *J+80ms*.

To make a selection, highlight your choice from the list of options.

ST Controls

The ST controls also offer buttons which open/activate other related areas/functions. These buttons are:

To Alarm Setup...

Close

12-Lead ECG Analysis

NOTE: 12-lead ECG analysis is an optional feature on the Solar 9500 Information Monitor. If enabled, the *12sl...* option will appear in the *Procedures* menu. If your institution has not purchased this option, it will not appear as an active selection in the *Procedures* menu.

NOTE: This feature is only available when using a Tram x51 series module or a Tram "SL" module.

WARNINGS

This device uses a computerized 12-lead ECG analysis program which can be used as a tool in ECG tracing interpretation. This computerized interpretation is only significant when used in conjunction with clinical findings. All computer-generated tracings should be overread by a qualified physician.

To ensure accuracy, use only computer-generated tracings and not the display for physician interpretation.

The intended use of this device is to record electrocardiograms and vectorcardiograms from surface ECG electrodes, not for positioning (floating) temporary pacemaker leadwires, performing pericardiocentesis, or other internal applications.

12-lead ECG Analysis Window

To access the 12-lead analysis window, select *12sl...* from the *ECG* lower control popup menu.

12-Lead Analysis Window

The 12-lead analysis window displays patient information, a diagnostic window showing the diagnosis of the most recent 12-lead analysis, a waveform window containing all 12 ECG waveforms, and control buttons.

All parameters continue to be monitored and values are displayed in the respective parameter windows.

Patient Information

The patient information shown in the upper left corner of the 12-lead analysis window is automatically displayed from the information entered in the system at the time of patient admission. This information includes patient name, identification number, age, height, and weight.

Additionally, the following ECG measurements are displayed in this area of the window. These items are listed below.

Vent. rate—Units are beats per minute.

PR interval—Units are milliseconds.

QRS duration—Units are milliseconds.

QT/QTc—Units are milliseconds.

P-R-T axes

Diagnostic Window

The diagnostic window in the upper right corner of the 12-lead analysis window displays information regarding the most recent 12-lead analysis performed.

Waveform Window

The 12-lead analysis window shows waveforms for all 12 leads of ECG being analyzed. These waveforms are labeled, and can be shown in 4 x 2.5 - 1 rhythm, 4 x 2.5 - 3 rhythm, and 12 rhythm formats. Refer to *Setup...* for more information on 12-lead ECG waveform formats.

Control Buttons

The 12-lead analysis control buttons are located at the bottom of the 12-Lead Analysis window.

Start 12 lead

Select the *Start 12 lead* button to initiate a 12-lead ECG analysis.

Clear

Select *Clear* to clear the displayed 12-lead ECG analysis and return to the real-time waveform display.

Print

Select *Print* to initiate a printout of the displayed 12-lead ECG analysis. This will print to the printer defined for printing procedures in the *Select Printers...* window.

Store to Muse

Select *Store to Muse* to send the displayed 12-lead ECG analysis to the Muse system. When used, the Muse system allows a clinician to review the patient's entire cardiovascular history.

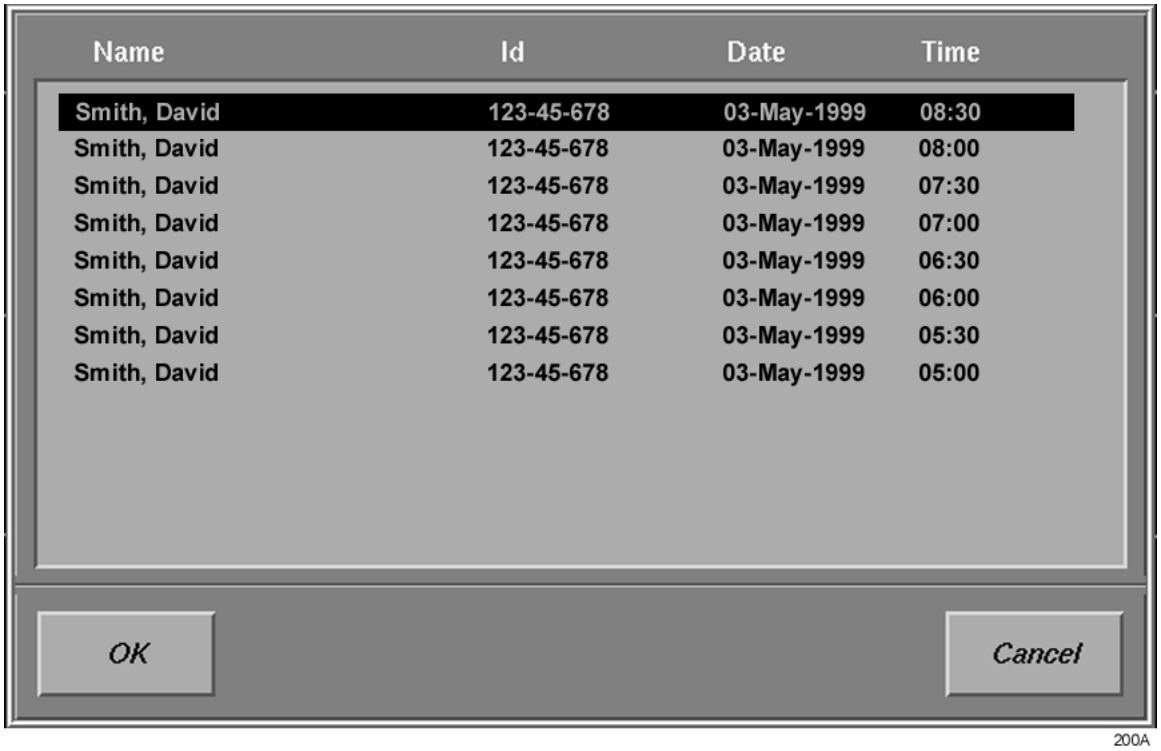
NOTE: You must select *Store to Muse* to initiate this action. 12-lead ECG analyses are not automatically sent to the Muse system.

Delete

Select *Delete* to delete the displayed 12-lead ECG analysis from the *12-lead Analysis* window. The delete process clears the 12-lead ECG analysis in question from the display and from the *Review* list.

Review

Select *Review* to open a window of saved 12-lead ECG analyses.



Review 12-Lead Window

All of the saved 12-lead ECG analyses are listed chronologically in this window, with the most recent 12-lead ECG analysis at the top of the list.

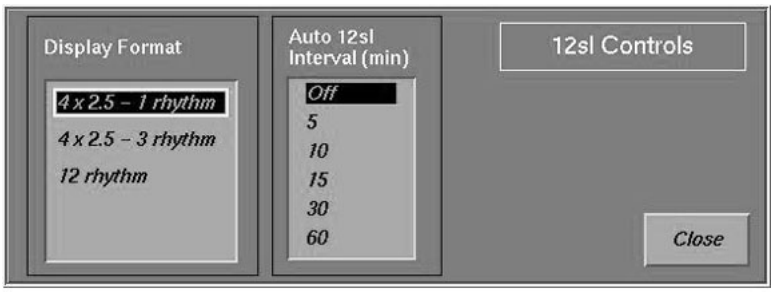
To review a 12-lead ECG analysis, follow these steps.

1. Select the 12-lead ECG analysis for review. It will be highlighted when selected.
2. Select *Ok* to activate your choice and to close the Review window.

   The 12-lead analysis selected for is now displayed, with all of the corresponding information reflected in the patient information area, diagnostic window, and waveform window.

Setup...

Select *Setup...* to open the *12sl Controls* window.



***12sl Controls* Window**

The options in the *12sl Controls* window allow you to modify the 12-lead ECG display format and the interval at which analyses are performed.

Display Format—The display format options are *4 x 2.5 - 1 rhythm*, *4 x 2.5 - 3 rhythm*, and *12 rhythm*. Highlight the format option of your choice. As soon as the format option is changed, the display reconfigures to accommodate the new selection.

Auto 12sl Interval—The options for automatic 12-lead ECG analyses are *Off*, *5 minutes*, *10 minutes*, *15 minutes*, *30 minutes*, and *60 minutes*. Highlight the interval option of your choice. Then select *Close* to activate your interval selection.

Close

Select *Close* to close the 12-Lead Analysis window.

Troubleshooting

Problem: Inaccurate heart rate and/or false asystole

Solution:

Check ECG signal from patient:

1. Check/adjust lead placement.
2. Check/perform skin preparation.
3. Check/replace electrodes.

Check amplitude of ECG waveform:

1. Touch or click in the ECG parameter window to open the *ECG Controls* window.
2. Select *ECG Lead*.
3. Scroll through all ECG leads and check for 0.5 mV amplitude at normal (x1) size. (At least 0.5 mV amplitude is required for QRS detection.) For borderline signals, validate on a graph.
4. If amplitudes are low, electrodes may need to be repositioned or replaced.

Relearn arrhythmia:

1. Touch or click in the ECG parameter window to open the *ECG Controls* window.
2. Select *Relearn*.

IF PROBLEM CONTINUES AND ECG AMPLITUDE IS LOW:

1. Touch or click in the ECG parameter window to open the *ECG Controls* window.
2. Select *ECG Size*.
3. Select *x2* or higher.
4. Select *Relearn*.
5. Close the *ECG Controls* window.

IF PROBLEM CONTINUES: Change to single lead ECG detection and processing:

1. Touch or click in the ECG parameter window to open the *ECG Controls* window.
2. Select *Lead Analysis*.
3. Select *Single Lead*.
4. Select *ECG Lead*.
5. Assess all the ECG leads and change top ECG waveform to display lead with greatest amplitude. (At least 0.5 mV amplitude is required for QRS detection.)

Problem: False ventricular calls

Solution:

Check ECG signal from patient: (The V lead may exhibit polarity changes which may occasionally cause an inaccurate call.)

1. Check/adjust electrode placement.
2. Check/perform skin preparation.
3. Check/replace electrodes. (If V lead is a problem, move the V lead to another V position or leg position.)
4. Relearn ECG:
    a. Touch or click in the ECG parameter window to open the ECG Controls window.
    b. Select *Relearn*.

IF PROBLEM CONTINUES:

1. Touch or click in the ECG parameter window to open the ECG Controls window.
2. Select *Relearn*.

Problem: Inaccurate pacemaker detection

Solution:

Use pacemaker processing:

1. Touch or click in the ECG parameter window to open the *ECG Controls* window.
2. Display the lead of ECG with the greatest amplitude in the top waveform position.
3. Select *Pacer Detect*.
4. Select *Pace 2* or *Pace 1*.

NOTE: Pace is only detected on the top displayed ECG lead.

Pace 2 pace mode does not count any complex within the next few milliseconds following the pacer spike; useful with A/V or atrial pacemakers with large P waves: most recommended mode for pace detection. Be aware that a pacemaker pulse could be falsely counted as a QRS during asystole.

Pace 1 pace mode looks at the ECG within the next few milliseconds following the pacer spike. If an event occurs during that time, it will be counted. This mode may be more useful on patients with ventricular pacemakers. Be aware that a pacemaker pulse could be falsely counted as a QRS during asystole.

Check ECG signal from patient:

1. Check/adjust lead placement; use electrode placement guide for pacemaker patients.
2. Check/perform skin preparation.
3. Check/replace electrodes.

Problem: ST numerics displayed only for primary (top) lead

Solution:

Check whether single lead or multi-lead processing is selected. Numerics will only be displayed for the primary lead if single lead processing is active.

Problem: ST measurement points for ISO or J are incorrect.

Solution:

1. Touch or click in the ECG parameter window to open the ECG Controls window.
2. Select *Relearn*.

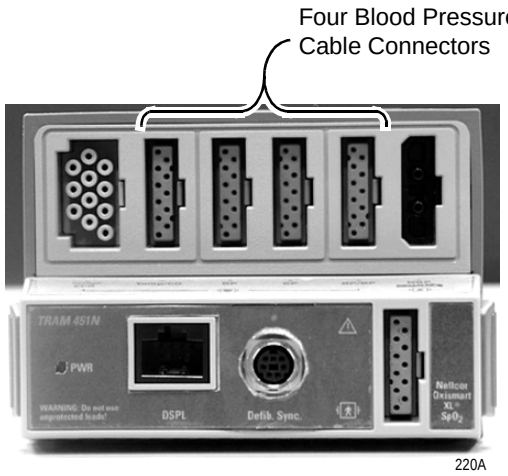
For your notes

10 Invasive Pressure Monitoring

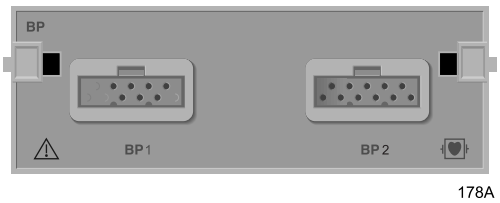
For your notes

Introduction

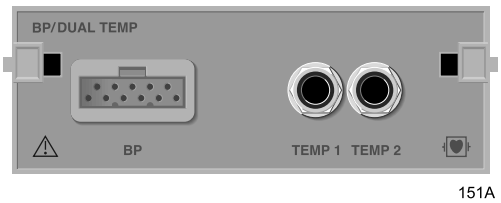
Invasive pressure monitoring is done with a Tram module which supports pressures, the dual BP module, or the BP/Dual Temperature module.



Tram Module



Dual BP Module



BP/Dual Temperature Module

NOTE: The signal input is a high-insulation port and it is defibrillator-proof ( ).

The insulated input ensures patient safety and protects the device during defibrillation and electrosurgery.

Assigned BP Names

Each invasive pressure connector is labeled BP on the module. For convenience, the monitor has a specific pressure name assigned for each BP connector. However, these names can be changed during the setup procedure, so you can plug any pressure line to any connector. Having names properly reflect the site is important for proper processing of the waveform since different algorithms are used for processing different pressure sites.

Site Names

Site names supported and values displayed are:

arterial (ART)—systolic, diastolic, mean and rate

femoral (FEM)—systolic, diastolic, mean and rate

umbilical arterial (UAC)—systolic, diastolic, mean and rate

pulmonary artery (PA)—systolic, diastolic, and mean

intracranial (ICP)—CPP and mean

umbilical venous (UVC)—mean

central venous (CVP)—mean

left atrial (LA)—mean

right atrial (RA)—mean

special (SP)—mean

BP Connector Names

The chart below shows the pressures assigned to the **BP** connectors on each of the Tram modules. For reference purposes, we refer to the connectors as **BP1**, **BP2**, etc., beginning with the left-most connector.

Assigned BP Names

	BP1	BP2	BP3	BP4	BP5	BP6	BP7	BP8
Tram modules with 2 BP connectors	ART	PA	—	—	—	—	—	—
Tram modules with 3 BP connectors	ART	PA	CVP	—	—	—	—	—
Tram modules with 4 BP connectors	ART	PA	CVP	LA	—	—	—	—
BP modules	—	—	—	—	ART	PA	CVP	LA

The invasive pressure labels will be displayed on the monitor with a number (1-4) associated with numbers printed on the Tram-rac housing. The number identifies the location of the connector in the Tram-rac housing, for example, ART1 and PA2 are the first and second BP connectors on a Tram module residing in the first slot of the housing.

Zero Reference

NOTE: Prior to monitoring, zero transducers at the patient's phlebostatic axis.

Zeroing the pressure transducers is very important for accurate pressure measurements. Transducers should be zeroed frequently and always before initiating treatment changes based on the pressure data. You can zero all transducers at one time or each one individually.

To zero all the pressure transducers at one time, follow this procedure:

1. Close the transducer stopcock(s) to the patient.
2. Open the venting stopcock(s) to air (atmosphere).
3. Select the *Pressures* lower control button, and select *ZERO ALL* from the popup menu.
4. Verify that zero reference has been established. (Watch the pressure parameter windows for messages.)
5. Close the venting stopcock(s) to air (atmosphere).
6. Open the transducer stopcock(s) to the patient. Within seconds pressure numerics should be displayed in the pressure parameter windows.

Checklist

1. The module is securely inserted in the Tram-rac housing.
2. Patient cable is attached to the **BP** connector on the module.
3. Transducers are level according to unit policy. (Recommended standard is level of right/left atrium.)
4. All transducers are zeroed.
5. Any entrapped air is removed from the system.

   NOTE: Refer to the transducer manufacturer's instructions for suggested means of removing entrapped air from the hydraulic system.

6. Pressure setup is adjusted, if necessary. Details are provided in this chapter.

Pressure Monitoring

The monitor accepts invasive blood pressure information gathered by the modules. Additionally, it displays all pressure-related messages from the modules.

The monitor provides controls to invoke the following programs and messages from the modules: Smart BP and IABP.

Smart BP

Smart BP is an arterial (femoral) artifact rejection program which substantially reduces the occurrences of needless alarms by eliminating most of the alarms associated with zeroing the transducer, fast flushing the system, and drawing blood.

When Smart BP is on, and the system recognizes one of these events, the arterial (femoral) alarms are deactivated and the systolic and diastolic numerics are replaced with dashes (––). The message "*Artifact*" is displayed. The mean pressure value is displayed throughout the artifact occurrence.

Safety Features: If zeroing, fast flushing, or drawing blood is not accomplished within certain time frames, alarms will sound. When artifact is detected, Smart BP begins to search for the return of a pulsatile pressure. When 15-20 beats have been detected, numerics are displayed and alarms are reactivated. If pressure remains below 10 mmHg for more than 14 seconds, the alarms will reactivate. During sustained high pressure (drawing blood or flushing the catheter), you have a maximum of two minutes before alarms reactivate.

The default condition for Smart BP is *Off*.

IABP

Intra-aortic balloon pump (IABP) monitoring is a feature of pressure sites named ART and FEM. When using an intra-aortic balloon pump, set up the monitor as described in this section.

Triggering

IMPORTANT — GE Medical Systems *Information Technologies* recommends that the signal source used to trigger an intra-aortic balloon pump (IABP) should be the balloon pump device itself. This insures that the trigger signal is compatible with all modes of the IABP. An extra set of ECG electrodes, or an additional connection from the arterial line can be connected to the monitor to produce waveforms on the monitor's display for consolidated waveform viewing.

WARNING
PATIENT HAZARD: If you choose to trigger the balloon pump from the monitor, contact the balloon pump manufacturer directly for interface requirements as they vary between manufacturers. Some trigger modes on certain balloon pump devices may not be compatible with GE Medical Systems *Information Technologies*' analog output signal, and use may contribute to patient injury or sub-optimal pumping results.

If you choose to use the monitor for triggering, you must follow the instructions below. Failure to follow these instructions may result in an incompatible analog output signal which may contribute to patient injury.

1. Contact the balloon pump manufacturer for interface requirements. GE Medical Systems *Information Technologies*' ECG analog output delay specification is shown in the table below.

Product	Maximum ECG Analog Output Delay Spec with Diagnostic ECG Filter*
Tram module	less than 25 milliseconds

** Refer to Step 2*

2. Cable connection and ECG filter.
   - Use the appropriate compatible analog output cable from GE Medical Systems *Information Technologies*.
   - Cable the balloon pump to the monitor through the **DEFIB SYNC** connector on the Tram module.
   - Use the Diagnostic ECG filter (.5 – 120 Hz, selected in the ECG menu).

3. Primary displayed ECG lead. If the balloon pump triggers off the P wave of the QRS complex, review the patient's ECG leads and place the one with the greatest amplitude in the top (primary) position on the monitor's screen.
4. Pacemaker Detection. If the patient has a pacemaker, be sure pacemaker detection is on (selected from the ECG menu). Failure to turn pacemaker detection ON may cause poor beat detection which may result in inadequate triggering of the balloon pump.

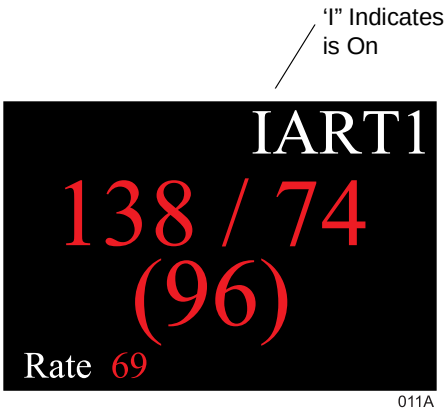
Using the IABP Feature

The monitor measures arterial (femoral) pressure and displays both the pressure waveform and numerical pressure values. The IABP feature compensates for the irregularities in the pressure waveform caused by the use of an intra-aortic balloon pump.

Turning IABP Program On

To turn the IABP program on and off, select *IABP* option from the *Pressure Controls* window for ART or FEM. Choices are *On* and *Off*. The default selection for the IABP program is *Off*.

When on, the parameter label will begin with an "I" as shown in the figure below.



ART Parameter Window with IABP Turned On

Displayed Values

Displayed pressure values are affected by the intra-aortic balloon pump.

The IABP program will display three values, for example 150 / 45 (98). The first value, systolic, is the highest pressure in the last three cardiac cycles; the second, diastolic, is the lowest pressure in the last three cardiac cycles; and the third (mean) is the average pressure during one cardiac cycle.

The displayed numerical values are computing a rapidly varying waveform generated during IABP treatment and do not always reflect a true arterial pressure. For accuracy and reliability, always combine two or more of the recommended methods listed below for reading arterial and/or femoral blood pressure:

- the IABP waveform displayed on the screen (use scales for evaluation),
- a printed copy of the waveform (use scales for evaluation), or
- the balloon pump display if available.

Since there are a number of points along the IABP waveform that could be the displayed value, it is important for you to know which ones the program chooses. The values displayed will differ depending on the timing of the pump.

The default condition for IABP is *Off*.

1:1 or 1:2 Timing

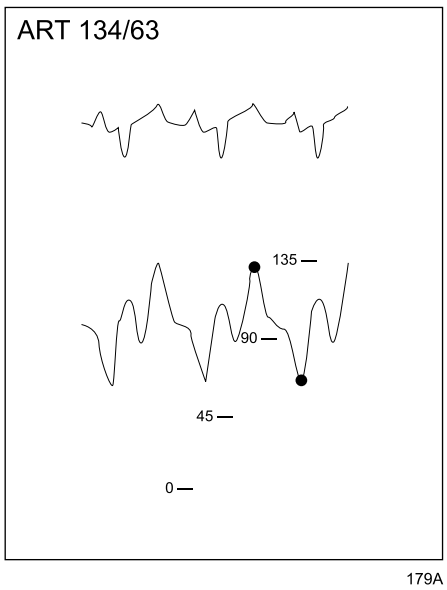


Figure 1
Augmented Diastole > Patient Systole

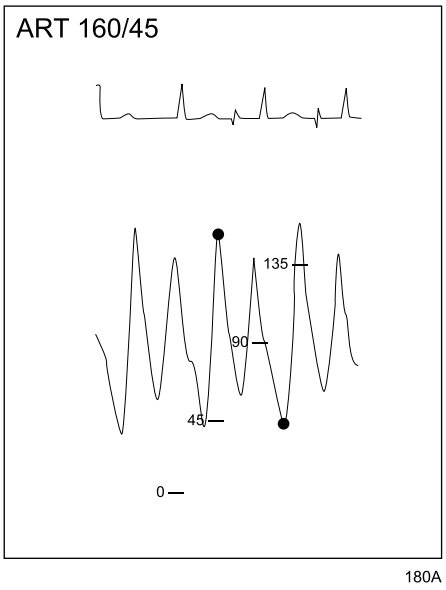


Figure 2
Patient Systole > Augmented Diastole

Systolic Numerics

- When the augmented diastole is greater that the patient systole, the displayed systole will equal the augmented diastole. (See figure 1.)
- When the patient systole is greater than the augmented diastole, the displayed systole will equal the patient systole. (See figure 2.)

Diastolic Numerics

- The displayed diastole will always equal the balloon end diastole. (See figures 1 and 2.)

1:3 or More Timing

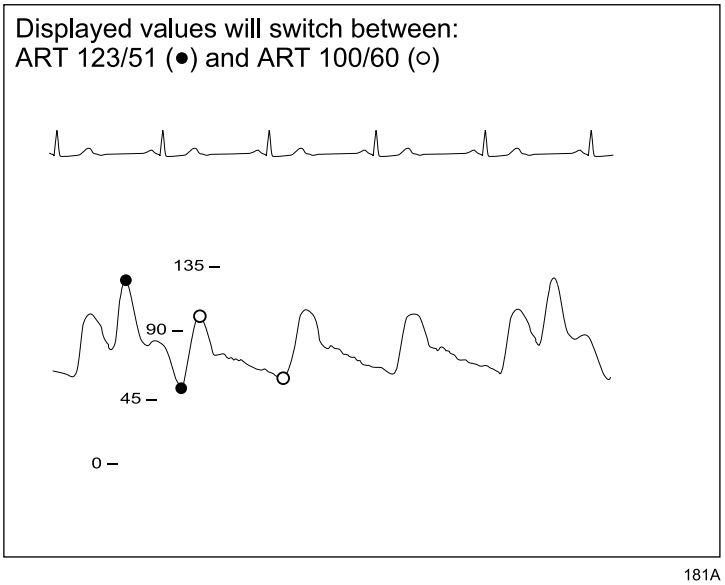


Figure 3

Systolic Numerics

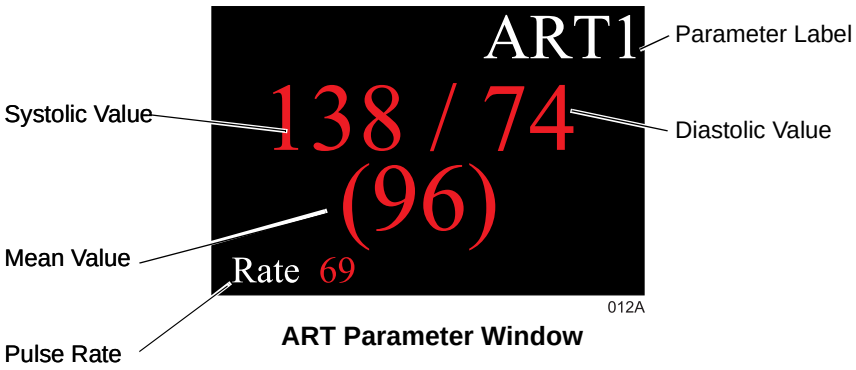
- The displayed systolic numerics will switch between the augmented diastole and patient systole. (See figure 3.)

Diastolic Numerics

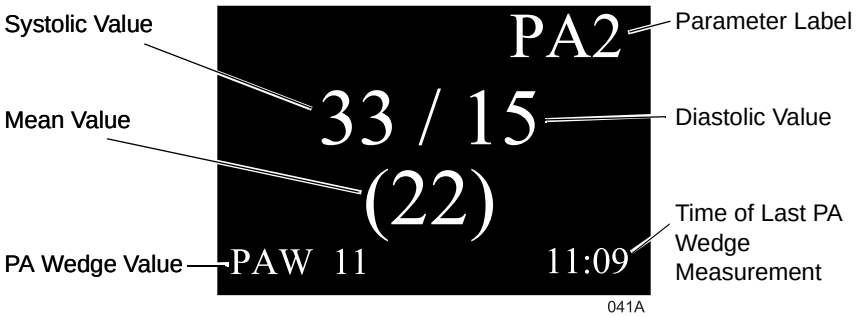
- The displayed diastolic numerics will switch between the balloon end diastole and the patient end diastole. (See figure 3.)

Invasive Pressure Parameter Window Displays

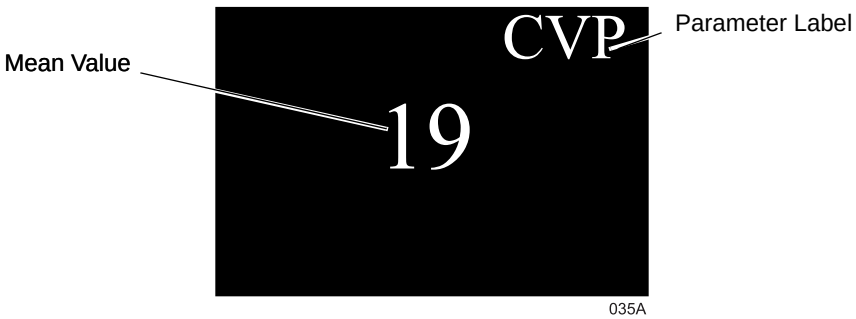
The parameter windows for ART, PA, FEM, and UAC display systolic, diastolic, and mean values. ICP displays CPP and mean values. All other invasive pressure parameter windows display only mean values.



ART Parameter Window



PA Parameter Window



CVP Parameter Window

Invasive Pressure Waveform Displays

Configuration

The waveforms for invasive pressures can be configured in individual, full, or free mode. This is set up via the waveform configuration window, accessed by selecting the *Configure Window…* button in the waveform window. For more information on configuring waveforms, refer to "Configuring Waveform Windows" in Chapter 1, The Basics.

Individual Mode

In individual mode, each pressure has its own scale. Lines indicating scale separate the pressure waveforms.

Full Mode

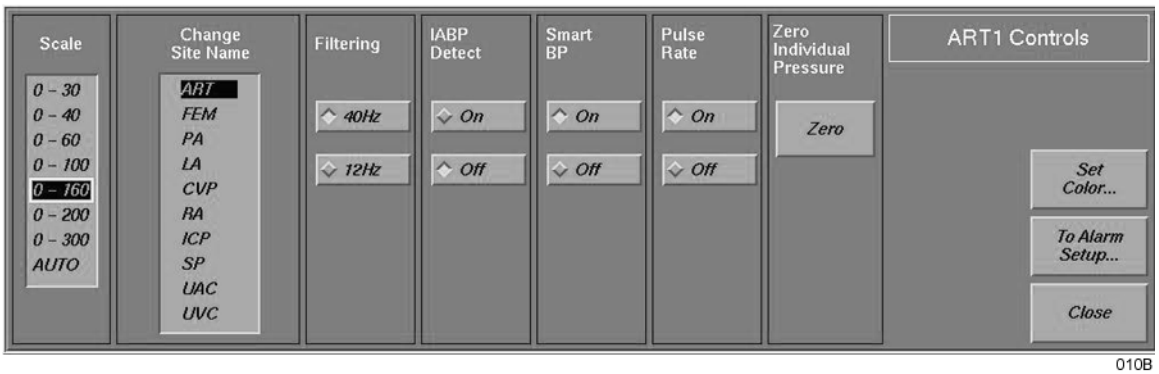
In full mode, up to eight invasive pressures can be displayed on an overlapping scale. Pressures located on the left side of the heart have scale units displayed on the left side of the overlapping waveform area. Pressures located on the right side of the heart have scale units displayed on the right side of the overlapping waveform area.

Free Mode

In free mode, the pressure waveforms are displayed without scales or graticules.

Invasive Pressures Controls Window

All invasive pressures share a similar control window. The control window that opens depends on the button or parameter window used to access it.



***ART1 Controls* Window**

General Information

The label in the upper right corner will be *"ART1 Controls"* or *"PA2 Controls,"* etc., reflecting the name of the invasive pressure site selected.

For any pressures except ART, FEM, and UAC, the *Pulse Rate* control will be unavailable.

For any pressures except ART and FEM, the *IABP Detect* and *Smart BP* controls will be unavailable.

For PA, the *To PA Wedge* button will be available.

The default selections for scale change is based on the pressure displayed.

When the monitor is in full mode, the *Scale* control will affect the right or left side, depending on which pressure has been selected.

Controls

Scale

The *Scale* control is a choice list. The scale options listed are fixed, but the default changes depending on the pressure displayed. To choose a scale, highlight your choice.

Scale Options

0 – 30
0 – 40
0 – 60
0 – 100
0 – 160
0 – 200
0 – 300
Auto

NOTE: Selecting *AUTO* is a one-time command. It does not continuously update the scales as the pressure changes.

AUTO is not available when the waveform window is in full display mode.

Change Site Name

This option allows you to change the designated name for this pressure connector. Remember, when using the Tram module, the monitor has preset names for each pressure connector in relation to its location in the Tram module and Tram-rac housing. (Refer to this chapter, Assigned BP Names.)

Having the names properly reflect the site is important for proper processing of the waveform since different algorithms are used for different pressure sites.

To make a selection from this choice list, highlight your choice.

Filtering

The *Filtering* option allows you to select either a *40Hz* filter or a *12Hz* filter for pressures.

The 12 Hz filter is recommented for typical monitoring applications. The 40 Hz filter allows higher frequency waveform components to be processed. This may result in elevated pressure values.

IABP Detect

ART and FEM only

To turn the IABP program on and off, select the *IABP Detect* option from the pressure controls window for ART or FEM. Choices are *On* and *Off*. The default selection for IABP detect is *Off*.

When on, the parameter label will begin with an “I” as shown in the figure on page 8 of this chapter.

Smart BP

ART and FEM only

To turn Smart BP on/off, select the *Smart BP* option from the pressures controls window for ART or FEM. Choices are *On* and *Off*. The default selection for Smart BP is *Off*.

Pulse Rate

ART, FEM, and UAC only

The *Pulse Rate* control displays an arterial pulse rate in the ART, FEM, or UAC parameter windows. No other control panels have this option.

NOTE: When using a Tram module, there must be at least a 10 mmHg difference between systolic and diastolic pressures to calculate a pulse rate.

When using a BP module, there must be at least a 5 mmHg difference between systolic and diastolic pressures to calculate a pulse rate.

Zero Individual Pressures

Selecting *Zero* in the *Zero Individual Pressure* control will apply the zero functions only to the pressure that has been selected.

Invasive Pressure Controls

The invasive pressure controls also offer buttons which open/activate other pressure-related areas/functions. These are:

To PA Wedge… (available only in the *PA Controls* window)

Set Color…

To Alarm Setup…

Close

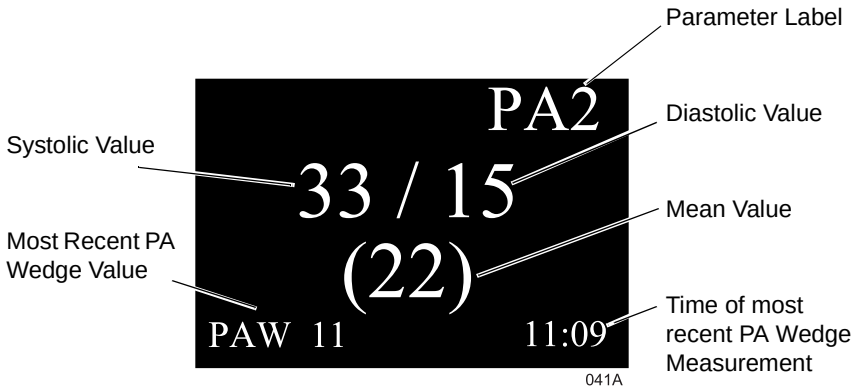
PA Wedge

The monitor accepts PA wedge waveforms and values from the Tram module or from the BP module.

To start the PA wedge program, select the *Procedures* lower control button, and choose *PA Wedge*. This simultaneously opens the PA wedge procedure window and initiates the auto PA wedge measurement. Selecting *Wedge* in the PA control window also opens the wedge procedure window and initiates the auto PA wedge measurement.

PA Parameter Window Display

When PA is being monitored, the PA wedge value is displayed in the PA parameter window.



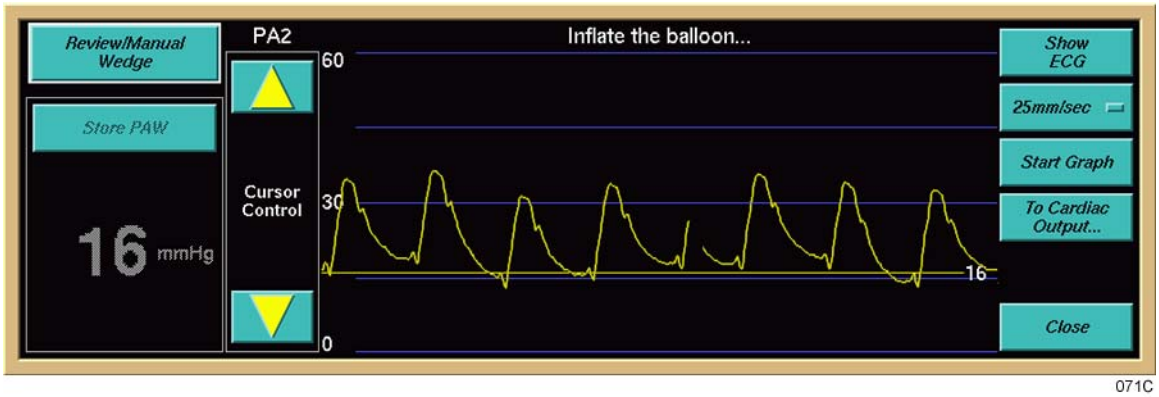
PA Parameter Window

PA Wedge Procedure Window

To access the PA wedge procedure window, select *PA Wedge* from the *Procedures* popup menu, or select the *To PA Wedge* button in the *PA Controls* window.

The PA wedge procedure window displays a large waveform of the PA pressure, and offers controls to determine the PA wedge pressure. As soon as this window is opened, the PA wedge procedure is automatically initiated.

The auto mode defaults on. A single beep sounds, and *Inflate the balloon…* is displayed at the top of the PA wedge procedure window. The program is ready and waiting for the balloon to be inflated.



PA Wedge Procedure Window

Review/Manual Wedge

Selecting *Review/Manual Wedge* allows you to review, analyze, and retake your wedge reading, if necessary. Refer to "Review/Manual Wedge" in this chapter for more information.

Show ECG/Hide ECG

The *Show ECG* button shows and hides a time-synchronized ECG waveform along the top of the PA wedge procedure window. To display the time-synchronized ECG waveform, select this button. To hide this ECG waveform, select this button again.

NOTE: The ECG parameter must be active when entering the PA wedge procedure window for this option to be available.

Waveform Speed

Select the waveform speed option to change the speed at which the ECG and pressure waveforms move through the wedge window. The button label reflects the current speed (e.g., *25mm/sec*).

Store PAW

When you are satisfied with the PA wedge value, select the *Store PAW* button to save the value to trends and include it with cardiac calculations. PA wedge values are also saved automatically when the PA wedge procedure window is closed.

Start Graph/Stop Graph/Print

While the PA wedge is being performed, a continuous manual graph of the waveform can be printed by selecting the *Start Graph* button. During the manual graph printout, the button label changes to *Stop Graph*. Select *Stop Graph* to stop the manual graph.

Once the PA wedge is complete, the button label changes to *Print*. Select *Print* to print a 15 mm/sec single-paged report of the displayed waveform. The *Print* option is also active when the *Review/Manual Wedge* option is selected.

Other Options

The PA Wedge procedure window also offers buttons which open/activate other related areas/functions. These buttons are:

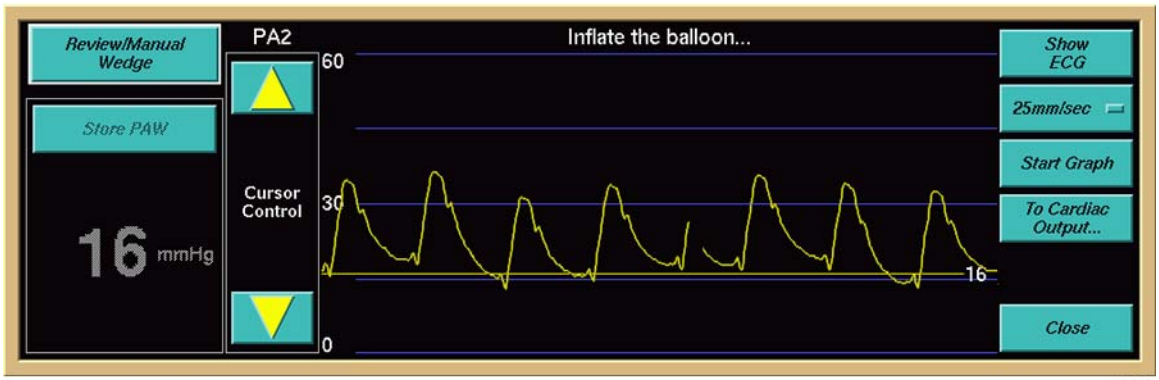
To Cardiac Output...

Close

PA Wedge Procedure

To take a PA wedge measurement, follow these instructions:

1. Select *PA Wedge* from the *Procedures* popup menu. The auto mode defaults on. Watch for the *Inflate the balloon...* prompt. You will hear a tone when it is displayed.



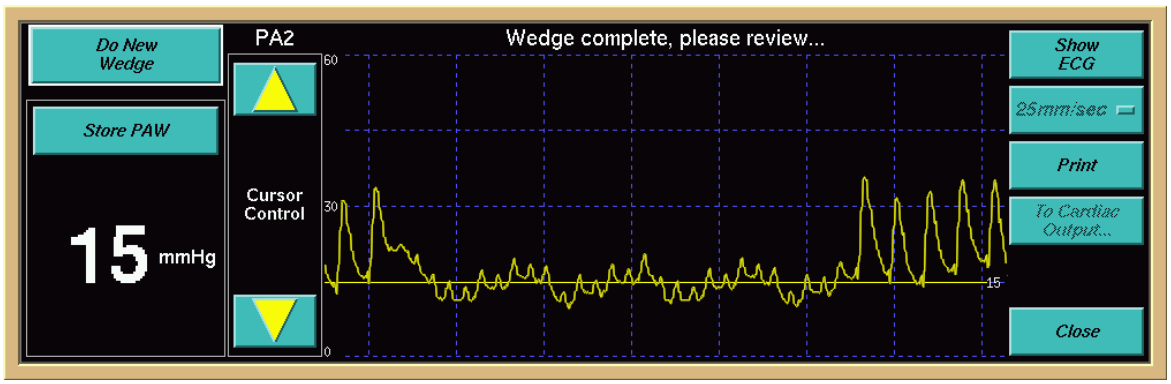
071C

   The manual cursor is active and is controlled by the arrow keys.

2. Inflate the balloon. The PA program will look for a pressure drop corresponding to balloon inflation and begin processing an end-expiration wedge value. The prompt in the PA wedge procedure window changes to *Wedging*.

3. Deflate the balloon when you feel wedging is adequate (3–4 respiratory cycles, but no longer than 20 seconds). The prompt in the parameter window now reads *Wedge complete, please review...*

   A program cursor (horizontal yellow line) is placed on the compressed PA waveform at end expiration and a wedge value corresponding to the cursor position is displayed. The scale displayed is automatically determined from the scale selected in the *PA Controls* window. If the PA wedge value is satisfactory, select *Store PAW* to save it to trends and include it with cardiac calcs.



076B

The PA wedge value and the time of measurement are then displayed in the PA parameter window.

Moving the Cursor

If you don't agree with the placement of the cursor for the PA wedge pressure value, you can change it using the cursor up and down buttons. When you are satisfied with the position of the cursor and the PA wedge value, select *Store PAW* to save the PA wedge value or close the window (wedge value saved automatically).

Review/Manual Wedge

The *Review/Manual Wedge* button freezes and unfreezes the PA waveform in the PA wedge procedure window. To review the current PA waveform, select this button. A cursor is inserted on the waveform at the mean value.

To move the cursor position on the PA wedge waveform, use the up and down arrows. This allows you to manually take a wedge measurement by adjusting the position of the cursor on the PA wedge waveform. The numeric value of the cursor's current position is displayed in the lower left side of this window.

Do New Wedge

After the *Review/Manual Wedge* button has been selected, its label changes to *Do New Wedge*.

Selecting *Do New Wedge* restarts the PA wedge automatic measurement or lets you do a manual reading. Use the cursor control arrows to move cursor to the desired position.

To store the PA wedge measurement, select *Store PAW*. To print the PA wedge measurement, select *Print*. To open the cardiac output procedure window, select *To Cardiac Output...*. To close the wedge review window, select *Close*.

Using the PA Wedge Value

Before the *To Cardiac Output...* button is selected from the PA wedge procedure window, the value corresponding to the cursor must be stored as the wedge value. This stored PA wedge value assumes the time the wedge procedure was done rather than the time that the *To Cardiac Output...* button was selected.

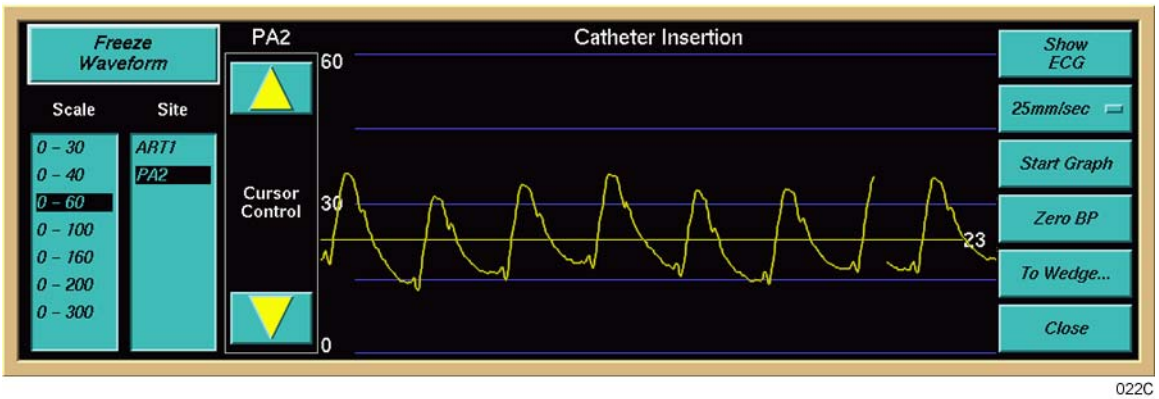
Catheter Insertion

Catheter Insertion Window

The catheter insertion procedure is used:

- When floating a Swan-Ganz catheter in place
- When evaluating a waveform with a cursor, e.g., IABP

To open the *Catheter Insertion* procedure window, select *Catheter Insertion…* from the *Procedures* popup menu.



Catheter Insertion Procedure Window

Freeze Waveform/Real time Waveform

The *Freeze Waveform* option freezes the waveforms in the *Catheter Insertion* window. When the waveform is frozen, the button label changes to *Real time Waveform*. When *Real time Waveform* is selected, the waveforms are unfrozen.

Scale

The *Scale* option allows you to change the reference scale of the waveform.

Site

The *Site* option is a choice list that allows you to change the waveform to be viewed in the *Catheter Insertion* procedure window. The list consists of the pressures that are currently being monitored. The scale of the waveform corresponds to the site selection.

Cursor Control

Use the cursor up and down buttons to change the placement of the cursor for the catheter insertion.

Show ECG/Hide ECG

The *Show ECG* button shows and hides a time-synchronized ECG waveform along the top of the *Catheter Insertion* procedure window. To display the time-synchronized ECG waveform, select this button. To hide this ECG waveform, select this button again.

Waveform Speed

Select the waveform speed option to change the speed at which the ECG and pressure waveforms move through the *Catheter Insertion* window. The button label reflects the current speed (e.g., *25mm/sec*).

Start Graph/Stop Graph

A continuous manual graph of the selected BP waveform can be started by selecting the *Start Graph* button. Once a manual graph is in process, the button label changes to *Stop Graph*. Selecting the *Stop Graph* button will stop the graph in process.

Other Options

The *Catheter Insertion* procedure window also offers buttons which open/activate other related areas/functions. These buttons are:

Zero BP

To Wedge...

Close

General Troubleshooting

Problem: Displayed pressure values are different than expected

Solution:

Check tubing for bubbles.

Remove excessive tubing.

Check phlebostatic axis placement of transducer.

Rezero pressure:

1. Close transducer stopcock to patient.
2. Open the venting stopcock to air.
3. Press *Zero All*.
4. Close the venting stopcock to air.
5. Open transducer stopcock to patient.

Is patient on IABP? If so, check to see if monitor's IABP program is turned on. Look for an I in the ART parameter window. If necessary, turn IABP program on:

1. Open the *ART Controls* window.
2. Under *IABP Detect*, select *On*.

Problem: Smart BP is on. Artifact is sensed without flush, draw, or zero

Solution:

Turn Smart BP *Off* then *On*. If problem persists, you may need to disable Smart BP by turning it off for that pressure.

Use the Alarm Pause feature prior to drawing blood to reduce unnecessary alarms if Smart BP is disabled.

Wedge Troubleshooting

NOTE: Confirm correct catheter placement prior to initiating troubleshooting efforts.

Problem: Unable to detect wedge

Solution:

Use the manual method for PA wedge measurement:

1. Select *Review/Manual Wedge* in the PA wedge procedure window.
2. Perform wedge measurement in manual mode following the procedure described earlier in this chapter.

Problem: Monitor displays "*Wedging*" when balloon has not been inflated

Solution:

Select *Do New Wedge* to begin wedge processing again.

If wedge is again detected due to resp artifact on PA waveform, then use the manual method for PA wedge measurement:

1. Select *Review/Manual Wedge* in the PA wedge procedure window.
2. Perform wedge measurement in manual mode following the procedure described earlier in this chapter.

Problem: Displayed wedge measurement is different than expected

Solution:

1. Repeat wedge measurement allowing a minimum of three respiratory cycles of data.
2. Verify end-expiration using the respiratory waveform on the display and observing patient's breathing pattern.
3. Adjust PA wedge cursor to end-expiratory wedge value.

Problem: Selecting the *Print* button doesn't send a graph of the wedge waveform to the printer

Solution:

The graph generated when the *Print* button is selected is sent to the *Procedures* printer. Verify which printer has been selected as the *Procedures* printer and check that printer for your graph. See Chapter 5, Printing, for more information.

NOTE: The graph generated when the *Start Graph* button is selected (during a PA wedge procedure) is sent to the printer selected as the *Manual Graph* printer.

For your notes

11 NBP Monitoring

For your notes

Introduction

The Solar 9500 Information Monitor only accepts NBP information from the Tram module. The Solar 9500 monitor values are based on the oscillometric method of noninvasive blood pressure measurement and correspond to comparisons with intra-aortic values within ANSI/AAMI Standards for accuracy.

WARNINGS

Noninvasive blood pressure monitoring is not recommended for patients experiencing seizures or tremors, or patients with hypotension, hypertension, arrhythmias, or extremely high or low heart rate. The software algorithm cannot accurately compute NBP on patients with these conditions.

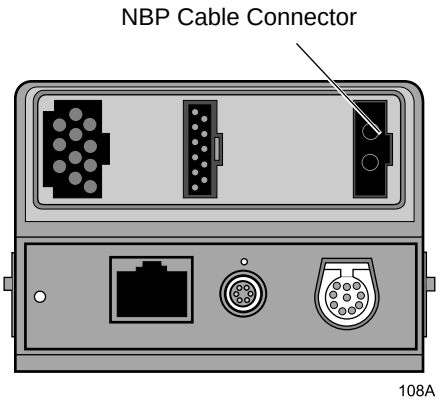
Do not use noninvasive blood pressure monitoring for neonatal and infant patients unless the precautions in this manual are followed.

Do not use noninvasive blood pressure cuffs with latex products.

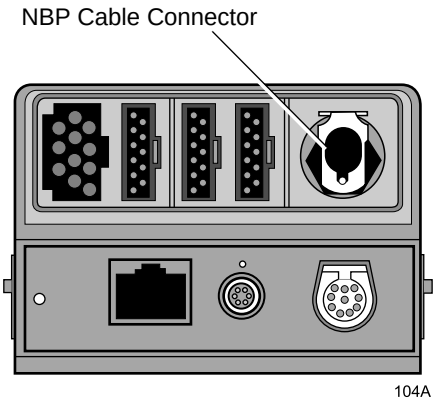
Automatic noninvasive blood pressure monitoring uses the oscillometric method of measurement. To understand how this method works, compare it to the auscultative method. With auscultation, the clinician listens to the blood pressure and determines the systolic and diastolic pressures. The mean pressure can then be calculated, as long as the arterial pressure curve is normal.

Since the monitor cannot hear the blood pressure, it measures cuff pressure oscillation amplitudes. Oscillations are caused by blood pressure pulses against the cuff. The oscillation with the greatest amplitude is the mean pressure. This is the most accurate parameter measured by the oscillometric method. Once the mean pressure is determined, the systolic and diastolic pressures are calculated with reference to the mean.

Simply stated, auscultation measures systolic and diastolic pressures and the mean pressure is calculated. The oscillometric method measures the mean pressure and determines the systolic and diastolic pressures. Due to the difference in these methods, one cannot be used to check the accuracy of the other.



Tram 800SL Module



Tram 200SL Module

NOTE: Some Tram modules have a rectangular NBP connector, and others have a rounded connector. Examples of the two types are shown above.

Noninvasive blood pressure monitoring is done with an appropriate Tram module. This chapter gives guidelines for patient preparation and adjusting setup.

The monitor accepts non-invasive blood pressure (NBP) information gathered by the Tram module. The appropriate algorithm is activated at case setup time when the cuff size is selected or patient age is set.

Checklist

1. The module is securely inserted in the Tram-rac housing.
2. A cuff appropriate for limb size has been selected.
3. Cuff is properly placed on patient.
4. Patient cable is connected to module.
5. Tubes between the cuff and the monitor are not kinked, blocked, or leaking.
6. Correct *Cuff Size* has been selected from the *NBP Controls* window.

WARNING
The cuff size selected in the NBP Controls window and the cuff size used must be correct to obtain reliable NBP data and to prevent overpressure in neonatal or pediatric use.

7. Confirm that cuff is fully deflated before positioning on patient
8. Start an NBP reading following procedures as detailed in this section.

9. The measurement should be performed on the non-dominant arm. Roll up sleeve before measurement. Only very thin fabrics will not impair the measurement.
10. Check that rolled up sleeve does not constrict the vessels.
11. The arm should be placed on a surface that is level with the heart. The palm of the hand should face up.
12. Position the patient so that no external pressure is applied against cuff while monitoring. External pressure on the cuff may cause inaccurate blood pressure values.

Patient Preparation

Cuff selection and application are important. Inappropriate selection or improper application of the cuff will result in erroneous measurements.

WARNING
The system is designed for use with dual-hose cuffs and tubing. The use of single-hose cuffs with dual hose tubing can result in unreliable and inaccurate NBP data.

Use care when placing cuff on extremity used to monitor other patient parameters.

Do not place the cuff on a limb being used for intravenous infusion or any area where circulation is compromised or has the potential to be compromised.

Cuff Selection

1. Identify patient limb circumference.
2. Select appropriate cuff; limb circumference is identified on each cuff.

Cuff Placement

1. Place cuff around extremity being used.
2. Marking on cuff should match artery location.
3. Cuff should be 1 to 2 inches above the elbow if using brachial artery.
4. Tubing is immediately to the right or left of the brachial artery to prevent kinking when elbow is bent.

WARNING
Periodically check patient limb circulation distal to the cuff. Check frequently when using auto NBP in 1 and 2 minute intervals. The 1 and 2 minute intervals are not recommended for extended periods of time.

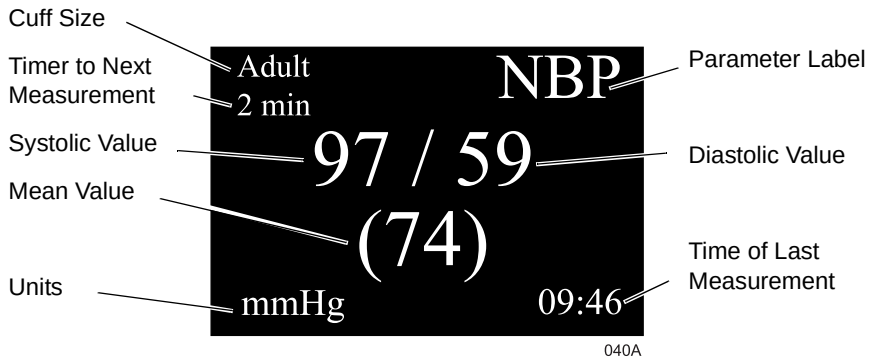
NOTE: Bruising may occur in some patients with normal use.

For further information on cuffs, please contact your sales/service representative.

NBP Parameter Data

NBP Parameter Window

The parameter window for NBP displays the time of the last measurement. Any NBP messages are shown in the NBP parameter window until cleared via the NBP control screen.



NBP Parameter Window

Mean Arterial Pressure

The following conditions may cause the NBP parameter block to display the mean arterial pressure (MAP) value while the associated systolic and diastolic values appear as Xs.

- Very low systolic and diastolic amplitude fluctuations (e.g., patients in shock).
- Very small difference between the MAP and the systolic pressure or the MAP and the diastolic pressure.
- Loss of system integrity (e.g., loose connections or worn parts). Be sure to perform a visual inspection to ensure system integrity.

Systolic Search

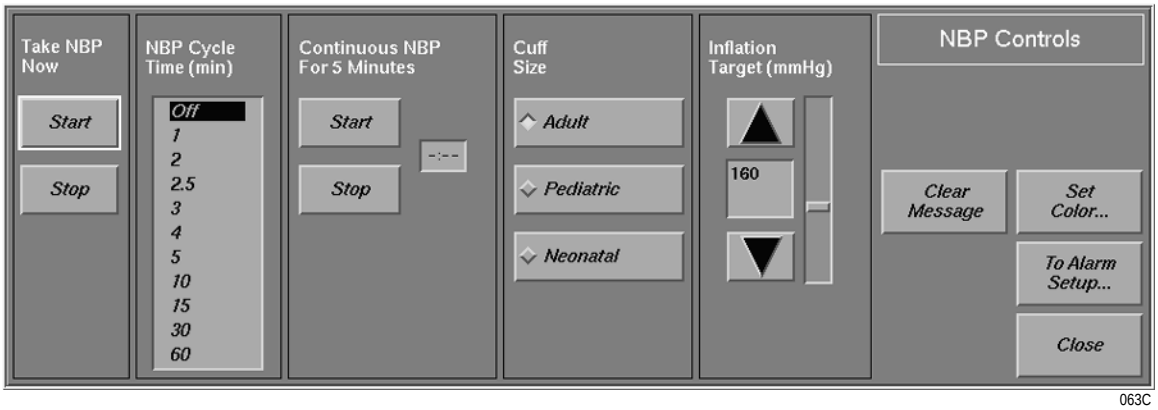
NOTE: The cuff target pressure must be higher than the patient's systolic pressure to obtain an accurate systolic and diastolic reading.

If a systolic blood pressure cannot be found, the monitor will search for a systolic reading by re-inflating the cuff at a higher pressure. This systolic search may occur once per NBP determination. During a systolic search, the maximum cuff inflation pressure will not exceed the normal pressure range of the cuff.

NBP Controls Window

Accessing the NBP Controls Window

To access the *NBP Controls* window, select the *Pressures* lower control button, and choose *NBP* from the popup menu. The *NBP Controls* window can also be opened by touching or clicking on the NBP parameter window.



***NBP Controls* Window**

NBP Controls

Take NBP Now

To take a NBP reading immediately, select the *Start* button. To stop a NBP reading that is in progress, select the *Stop* button.

NBP Cycle Time

NBP cycle time allows you to program the monitor to automatically take NBP measurements at specific time intervals. To select the time (in minutes) in the NBP cycle, highlight your choice from the list of options.

The NBP cycle time program is a timed cycle. If, when first turned on, it is set to run at 5-minute intervals, the cuff inflates immediately and then every 5 minutes thereafter. If you change the timing interval (e.g., 15 minutes) without turning the NBP cycle time off, the timing cycle does not start over. The next cuff inflation will occur 15 minutes after the last inflation and every 15 minutes thereafter. Turning the NBP cycle time off and then choosing a time interval again restarts the timing cycle with an immediate cuff inflation.

Continuous NBP for Five Minutes

To initiate five minutes of continuous sequential, automatic NBP readings, select *Start*. To interrupt the five-minute continuous NBP readings, select *Stop*. The monitor will then resume the NBP cycle as indicated.

Early Systolic Measurement

Early systolic measurement is a feature of the continuous NBP mode. As soon as you enter the continuous NBP mode, cuff inflation begins, a measurement is taken, and the systolic, diastolic, and mean values are displayed. Thereafter, the systolic value will be displayed shortly after the measurement starts. When the measurement is complete, the monitor will beep and the final measurement values will be displayed.

NOTE: This option only appears when the Tram module is running software version 10B or later.

Cuff Size

This option sets the monitor for the appropriate cuff inflation pressure. Select the appropriate cuff size — Adult, Pediatric, or Neonatal.

NOTE: The initial cuff size is automatically set when you enter the patient's age or date of birth in the Patient Information window (accessed through the Patient Data popup menu).

Clear NBP Message

To clear a message from the NBP parameter window, select *Clear Message*. The last valid NBP reading is then displayed in the NBP parameter window.

Also, pressing this button while an NBP reading is displayed will clear the measurement from the NBP parameter window.

Inflation Target

This option allows you to set the target inflation pressure for the first NBP measurement.

You can scroll through a selection of inflation pressures. The choices available depend on the cuff size selected. For adult and pediatric cuff sizes, the choices are 100 mmHg to 250 mmHg. For the neonatal cuff size, the choices are 100 mmHg to 140 mmHg.

Inflation pressures can be adjusted in increments of 5 mmHg within the inflation limits of the cuff size selected.

Cuff inflation thereafter is automatically determined by multiple factors, including the cuff size selected and the previous NBP reading.

Initial inflation pressure can also be set in the Setups menu.

NOTE: This option only appears when the Tram module is running software version 10B or later.

NBP Controls

The *NBP Controls* window also offers buttons which open/activate other related areas/functions. These buttons are:

Set Color

To Alarm Setup...

Close

Troubleshooting

NBP Status Messages

A status message will be displayed in the NBP values window if a measurement is unable to be completed. Following is an alphabetical list of some of the status messages with monitor response and action to take.

Status Message	Monitor Response	Solution
Cuff Inflation over 5 Minutes	System status alarm. Auto mode will shut off.	Check cuff, if no air is in cuff, try another measurement. If problem persists, contact service. If air is in cuff, remove cuff and contact service.
Deflation Fail, Remove Cuff	System status alarm. Auto mode will shut off.	Remove cuff and contact service.
NBP Hardware Malfunction	System status alarm. Auto mode will shut off.	Contact service.
No Determination	System status alarm.	Check patient and cuff placement; try another measurement. If problem persists, contact service.
Over Pressure	System status alarm. Auto mode will shut off.	Remove cuff and contact service.
Pump Timeout (inflation failure/pressure leak)	System status alarm.	Check connections between cuff and module; try another measurement. If problem persists, contact service.
Total Timeout (Measurement > 3 minutes)	System status alarm.	Possible excessive patient movement or arrhythmia condition. Check patient; try another measurement. For neonates, the status message will appear after 90 seconds.

Any two consecutive NBP status messages will shut *Auto* mode off if it is running.

A message will clear when the next measurement is initiated, or a message can be cleared manually with the *Clear* button in the *NBP Controls* window.

An NBP status message will also be included in the graph header when applicable.

Problem: Erroneous NBP measurement

Solutions:

1. Check for proper cuff size:
   a. Too small a cuff can give an erroneously high value.
   b. Too large a cuff can give an erroneously low value.
2. Check for residual air left in the cuff from a previous measurement.
3. Make sure cuff is not too tight or too loose.
4. Make sure cuff is not placed over heavy fabric.
5. Make sure cuff is properly placed with the marking on the cuff matching the appropriate artery.
6. Make sure cuff and heart are at same level, otherwise hydrostatic pressure will offset the NBP value.
7. Minimize patient movement during measurement.
8. Watch for pulsus paradoxis.
9. Check for leak in cuff or tubing.
10. Patient may have a weak pulse.
11. Calibration may be necessary. For information on NBP calibration, refer to the service manual.

12 SpO2 Monitoring

For your notes

Introduction

The Solar 9500 monitor only accepts SpO2 information from the Tram module.

WARNING
Do not use SpO2 monitoring for neonatal and infant patients unless the precautions in this manual are followed.

SpO2 monitoring is a noninvasive technique used to measure the amount of oxygenated hemoglobin and pulse rate by measuring the absorption of selected wavelengths of light. The light generated in the probe passes through the tissue and is converted into an electrical signal by the photodetector. The module processes the electrical signal and displays on the screen a waveform and digital values for SpO2 and pulse rate.

NOTE: Older Tram modules have the SpO2 connector labeled as SAO2.

SpO2 (pulse oximetry) monitoring is done with a Tram module with an SpO2 connector.

Tram Module

Module and Probe Compatibility

NOTE: Nellcor, GE Medical Systems *Information Technologies*, and Masimo pulse oximetry is calibrated to display functional saturation. Ohmeda pulse oximetry is calibrated to display fractional saturation.

- Tram x51 modules are compatible with GE Medical Systems *Information Technologies* probes.
- Tram x51M modules are compatible with Masimo LNOP probes.
- Tram x51N modules are compatible with Nellcor Oxismart XL probes. Other Nellcor cables cannot be plugged into this connector.
- Tram x00 modules with SpO2 are compatible with Ohmeda probes.
- Tram x50 modules are compatible with Nellcor and GE Medical Systems *Information Technologies* probes.

NOTE: The SpO2 cable should plug into the module's SpO2 connector easily and securely. Do not use excessive force to connect the cable. If the SpO2 cable does not easily fit into the SpO2 connector on the module, it is likely that you do not have the appropriate cable for that module.

Checklist

1. The Tram module is securely inserted in the Tram-rac housing.
2. SpO2 probe is correctly positioned on the patient. (Follow instructions provided with the probe of choice.)
3. Patient cable is connected to the Tram module.
4. SpO2 setup is adjusted, if necessary. Follow detailed procedures within this chapter.

Safety

WARNINGS

APNEA — A pulse oximeter should NOT be used as an apnea monitor.

EARLY WARNING — A pulse oximeter should be considered an early warning device. As a trend toward patient deoxygenation is indicated, blood samples should be analyzed by a laboratory co-oximeter to completely understand the patient's condition.

EXPLOSION HAZARD — Do not use the SpO2 modules in the presence of flammable anesthetics or other flammable substances in combination with air, oxygen-enriched environments, or nitrous oxide.

INTERFERING SUBSTANCES — Carboxyhemoglobin may erroneously increase SpO2 readings. The level of increase is approximately equal to the amount of carboxyhemoglobin present. Dyes, or any substance containing dyes, that change usual arterial pigmentation may cause erroneous readings.

MRI INTERFERENCE — Do not use SpO2 modules or probes during magnetic resonance imaging (MRI) scanning. Induced current could potentially cause burns. The module may affect the MRI image, and MRI unit may affect the accuracy of the oximetry measurements.

Measurements

If the accuracy of any measurement does not seem reasonable, first check the patient's vital signs by alternate means, then check the SpO2 module for proper functioning.

Inaccurate measurements may be caused by:

- Incorrect probe application or use.
- Significant levels of dysfunctional hemoglobins (e.g., carboxyhemoglobin or methemoglobin).
- Intravascular dyes such as indocyanine green or methylene blue.
- Exposure to excessive illumination, such as surgical lamps, bilirubin lamps, fluorescent lights, infrared heating lamps, or direct sunlight.

  NOTE: Exposure to excessive illumination can be corrected by covering the probe with a dark or opaque material.

- Excessive patient movement.
- Venous pulsations.
- Placement of a probe on an extremity with a blood pressure cuff, arterial catheter, or intravascular line.
- Excessive environmental motion or electromagnetic interference may prevent tracking of pulse. Measurements may seem inappropriate or the monitor may not seem to operate correctly.

The SpO2 modules can be used during defibrillation, but the readings may be inaccurate for a short time.

Neonates and Infants

WARNING
The display of inaccurate pulse oximetry (SpO2) values has been linked to the presence of poor signal strength or artifact due to patient motion during signal analysis. This condition is most likely to be encountered when the monitor is used on neonates or infants. These same conditions in adults do not impact the SpO2 values to the same extent.

When using pulse oximetry on neonates and infants, always observe the following precautions.

PRECAUTIONS

We recommend the application of the following criteria when using the pulse oximetry function on neonates and infants:

1. The peripheral pulse rate (PPR) as determined by the SpO2 function must be within 10% of the heart rate, and
2. the SpO2 signal strength indicator must have 2 or 3 asterisks displayed.

Procedures or devices previously applied in your facility for SpO2 monitoring should be used in the event that the SpO2 value from the monitor cannot be validated by the above criteria.

Patient Preparation

Prepare the patient for SpO2 monitoring using the following steps:

1. Choose the probe that is best suited to your patient—ear, finger, disposable, reusable, etc.

   NOTE: If you are using a Nellcor compatible module, Nellcor's RS-10 reflective probe is not recommended for use. Contact Nellcor for other probe options.

2. Clean the surface of the probe before and after each patient use.
3. Following the instructions provided with the probe, correctly position and attach the probe to your patient.

Be aware of the following general safety precautions when using SpO2 probes:

WARNINGS

DATA VALIDITY—Do not expose probe detector to strong ambient light while monitoring a patient. A poor signal may result.

DATA VALIDITY—Do not allow tape to block the probe light detector.

DATA VALIDITY—Check that the SpO2 waveform is physiological in shape. (Not applicable when monitoring SpO2 with a Tram x51M module.)

PATIENT SAFETY—Prolonged monitoring may require changing the probe site periodically. Move the probe if there is any sign of skin irritation or impaired circulation. Change the probe site at least every four hours to prevent ischemic skin necrosis. Be particularly careful when monitoring neonates. If required, reduce the application periods to half the times recommended above.

PATIENT SAFETY—If a probe is damaged in any way, discontinue use immediately.

Be sure to read all literature accompanying probes for specific safety information.

Signal and Data Validity

It is extremely important to determine that the probe is attached to the patient correctly and the data is verifiable. To make this determination, three indications from the monitor are of assistance—signal strength indicator, quality of the SpO2 waveform, and stability of the SpO2 values. It is critical to observe all three indications simultaneously when ascertaining signal and data validity.

Signal Strength Indicator

The signal strength indicator is displayed within the SpO2 parameter window. This indicator consists of 0 (weakest), 1, 2, or 3 (strongest) asterisks depending on the strength of the signal. Proper environmental conditions and probe attachment will help to ensure a strong signal.

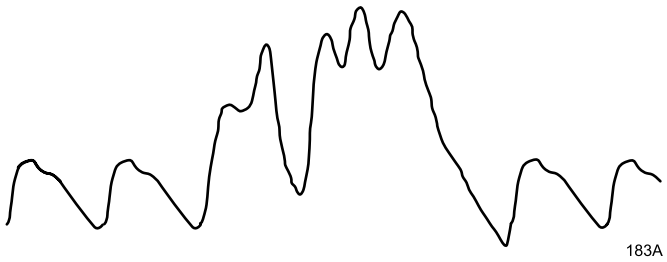
Quality of SpO2 Waveform

NOTE: This section is not applicable to monitoring SpO2 with Tram x51M modules.

Under normal conditions, the SpO2 waveform corresponds to the arterial pressure waveform. The typical SpO2 waveform indicates not only a good waveform, but helps the user find a probe placement with the least noise spikes present. The figure below represents an SpO2 waveform of good quality.

Good Quality SpO2 Waveform

If noise (artifact) is seen on the waveform because of poor probe placement, the photodetector may not be flush with the tissue. Check that the probe is secured and the tissue sample is not too thick. Pulse rate is determined from the SpO2 waveform which can be disrupted by a cough or other hemodynamic pressure disturbances. Motion at the probe site is indicated by noise spikes in the normal waveform. (See the figure below.) It has been noted that letting the patient view the SpO2 waveform enables them to assist in reducing motion artifact.



SpO2 Waveform with Artifact

Stability of SpO2 Values

The stability of the displayed SpO2 values can also be used as an indication of signal validity. Although stability is a relative term, with a small amount of practice one can become proficient at interpreting changes that are artifactual or physiological and the speed of each.

To aid you in successful SpO2 monitoring, messages are provided in the SpO2 window. Refer to the Troubleshooting section in this chapter.

WARNING

In the monitoring of patients the coincidence of adverse conditions may lead to a disturbed signal going unnoticed. In this situation artifacts are capable of simulating a plausible parameter reading, so that the monitor fails to sound an alarm. In order to ensure reliable patient monitoring, the proper application of the probe and the signal quality must be checked at regular intervals.

Masimo SET Modules and Probes

The Tram x51M modules are used to non-invasively measure the amount of oxygenated hemoglobin and pulse rate. The absorption of selected wavelengths of light is measured with Masimo LNOP probes. Although these modules process the SpO2 measurements differently, the function and appearance of SpO2 on your monitor is essentially the same as SpO2 monitoring with any other module.

No Implied License

Possession or purchase of this device does not convey any express or implied license to use the device with unauthorized replacement parts, which would, alone, or in combination with this device, fall within the scope of one or more of the patents relating to this device.

Probes

Before use, carefully read the Masimo LNOP probe directions for use.

Use only Masimo oximetry probes with the Tram x51M modules. Other probes (sensors) may cause improper performance.

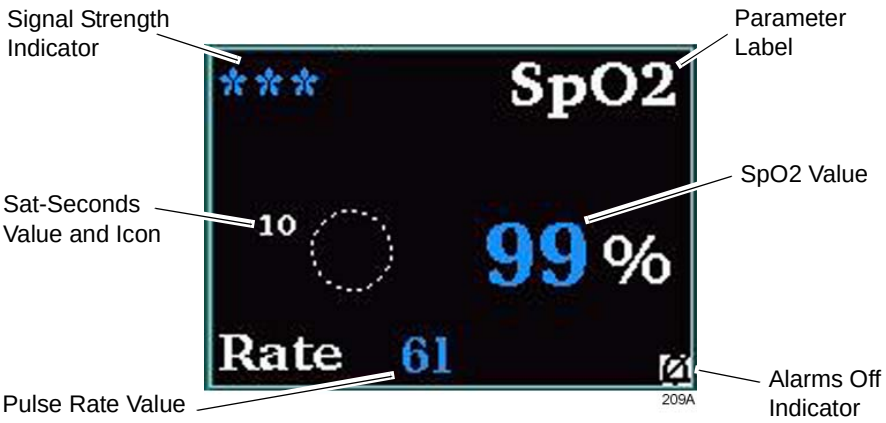
CAUTION
Tissue damage can be caused by incorrect application or use of an LNOP probe, for example by wrapping the probe too tightly. Inspect the probe site as directed in the probe's directions for use to ensure skin integrity and correct positioning and adhesion of the probe.

Do not use damaged LNOP probes. Do not use an LNOP probe with exposed optical components. Do not immerse the probe in water, solvents, or cleaning solutions. The probes are not waterproof. Do not sterilize by irradiation, steam, or ethylene oxide. See the cleaning instructions in the directions for use for reusable Masimo LNOP probes.

SpO2 Parameter Window Display

When SpO2 is monitored, its saturation value is centered vertically in the parameter window, the signal strength indicator is in the upper left corner, and the pulse rate is in the lower left corner.

NOTE: Visual indication of the patient's pulse is not proportional to the pulse amplitude.



SpO2 Parameter Window

SpO2 Information

The current SpO2 value and the derived pulse rate (*Rate*) are displayed. The asterisks indicate the strength of the signal (three asterisks indicate the strongest signal).

When monitoring SpO2 using Nellcor Oxismart technology (Tram x51N modules) and the Sat-Seconds feature is active, a Sat-Seconds value and icon are also displayed.

GE and Ohmeda SpO2 measurements are averaged over a 6-second period of time in adult mode and 12 seconds in neonatal mode. The different averaging time in neonatal mode is to help decrease false alarms related to patient motion artifact.

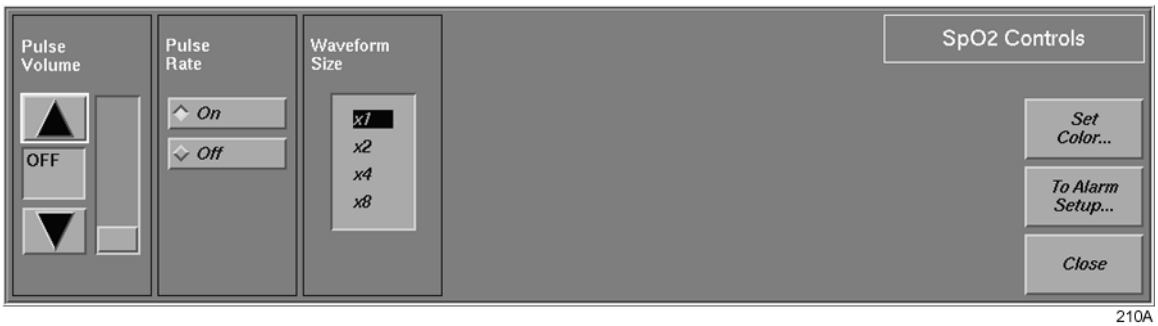
NOTE: The Tram x51M modules have adjustable averaging times.

The Tram x51N modules use Nellcor's standard averaging for all monitoring modes.

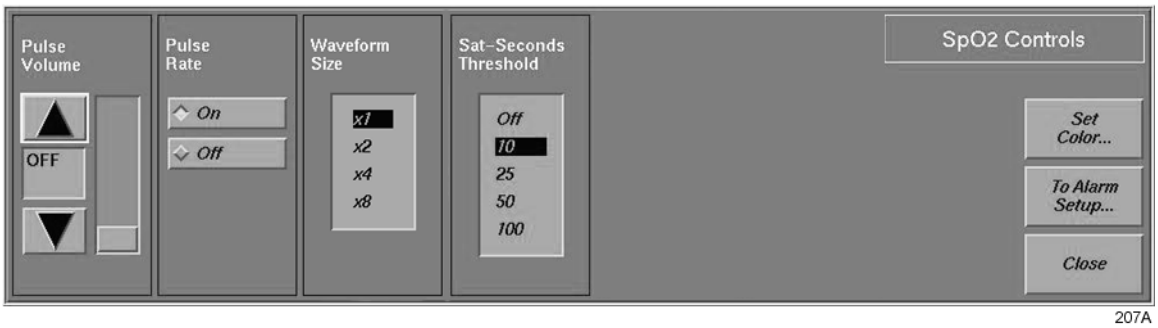
The monitor display is updated whenever the value changes.

SpO2 Controls Window

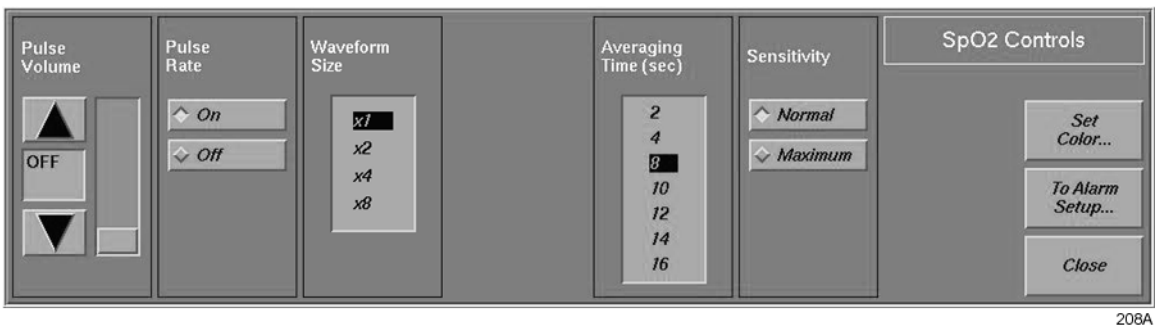
Selecting *SpO2...* from the *Respiratory* popup menu opens the SpO2 Controls window. The SpO2 Controls window can also be opened by touching or clicking on the SpO2 parameter window. The options in the SpO2 Controls window vary, depending on which type of Tram module you are using. Examples are shown below.



SpO2 Controls Window for GE, Ohmeda, and Nellcor (non-Oxismart) Probes



SpO2 Controls Window for Nellcor Oximart XL Probes



SpO2 Controls Window for Masimo SET Probes

Pulse Volume

The Pulse Volume control allows you to change the volume level. Use the up and down arrow buttons or the slide control to modify the volume level. The current volume level is indicated in a window.

The pitch of the SpO2 tone is not user adjustable. It is related to the SpO2 value, as illustrated in the table below.

SpO2 Value	Value Change Per 1/8 Tone Change
100 – 70	1
69 – 50	2
49 – 20	5

Pulse Rate

The *Pulse Rate* control allows you to turn the rate on and off in the parameter window. An indicator light is illuminated next to the active button's label. The default setting is *On*.

Waveform Size

The *Waveform Size* control allows you to change the size of the displayed SpO2 waveform. The choices are *x1, x2, x4,* and *x8*. The default size is *x1*.

Sat-Seconds Threshold

NOTE: This control only appears when using a Tram x51N module and a Nellcor Oxismart XL probe.

The *Sat-Seconds Threshold* control allows you to adjust the Sat-Seconds threshold. Refer to "Sat-Seconds Alarm Management" on page 12-16 for more information.

Averaging Time

NOTE: This control only appears when using a Tram x51M module and a Masimo probe.

The *Averaging Time (sec)* control provides selections for SpO2 averaging time. The default averaging time for all monitoring modes is 8 seconds.

NOTE: For the 2- and 4-second averaging settings, the actual averaging times may range from 2 to 4 seconds and 4 to 6 seconds, respectively.

Sensitivity

NOTE: This control only appears when using a Tram x51M module and a Masimo probe.

The *Sensitivity* control allows you to select *Normal* or *Maximum* sensitivity. The default setting is *Normal*.

- Use the *Normal* sensitivity setting for normal patient monitoring purposes.
- Use the *Maximum* sensitivity setting for improved low perfusion performance and for faster tracking of rapid SpO2 saturation changes.

CAUTION
Using the Maximum sensitivity setting delays the Probe Off Patient detection alarm.

SpO2 Controls

The SpO2 Controls window also offers buttons which open/activate other related areas/functions. These buttons are:

Set Color…

To Alarm Setup…

Close

Sat-Seconds Alarm Management

The Sat-Seconds (or saturation seconds) feature available with the Tram x51N modules uses Nellcor Oximart XL technology to decrease the likelihood of false SpO2 alarms caused by motion artifact.

This feature defaults OFF. It must be turned on by selecting a Sat-Seconds threshold in the SpO2 Controls window. When Sat-Seconds is turned on, the Sat-Seconds icon appears in the SpO2 parameter window (see page 12-12 for an example).

With traditional pulse oximetry alarm management, upper and lower alarm limits are set. During monitoring, as soon as a limit is violated, an alarm is generated.

With Sat-Seconds alarm management, upper and lower alarm limits are set in the same way as traditional alarm management. A Sat-Seconds limit is also set. This allows monitoring of SpO2 saturation outside the set limits for a period of time (count value) before an alarm sounds.

NOTE

The Sat-Seconds feature applies to SpO2 saturation only. It does not apply to peripheral pulse rate.

The *Sat-Seconds Threshold* control in the SpO2 Controls window allows you to set the Sat-Seconds limit. The Sat-Seconds limit controls the amount of time that SpO2 saturation may be outside the set limits before an alarm sounds.

NOTE

If the Sat-Seconds limit is set to *Off*, any SpO2 limit violation will cause an alarm.

The method of calculation is as follows: The number of percentage points that the SpO2 saturation falls outside the alarm limit is multiplied by the number of seconds that it remains outside the limit. This can be stated as the equation “points x seconds = Sat-Seconds,” where points equals SpO2 percentage points at or outside the limit, and seconds equals the number of seconds SpO2 remains at that point outside the limit.

NOTE

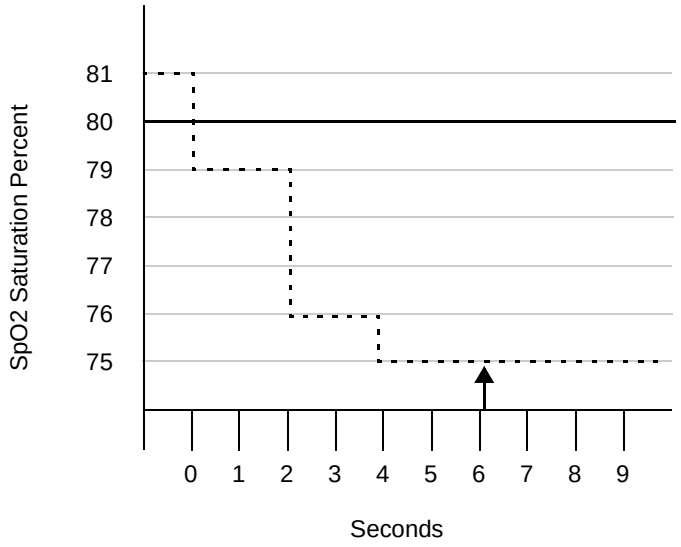
GE Medical Systems *Information Technologies* monitors sound an alarm when the parameter value is equal to the limit value. Therefore, an SpO2 saturation equal to the alarm limit is considered to be outside the limit. In other words, if a low limit were set to 80%, an SpO2 saturation of 80% would be a limit violation because 80% is the set low limit. An SpO2 saturation of 81% would be the nearest in-limit value.

For example, the figure below demonstrates the alarm response time with a Sat-Seconds limit set at 25 and a lower SpO2 limit of 80%.

In this example, the SpO2 level drops to 79% (2 points) and remains there for 2 seconds. Then it drops to 76% (5 points) for 2 seconds, and then to 75% (6 points) for 2 seconds. The resulting Sat-Seconds are:

SpO2 Saturation	Seconds	Sat-Seconds
2 x	2 =	4
5 x	2 =	10
6 x	2 =	12
Total Sat-Seconds		**26**

After approximately 6 seconds, the Sat-Seconds alarm would sound because 25 Sat-Seconds would have been exceeded (arrow in chart below).



Sat-Seconds Alarm Response Example

Saturation levels may fluctuate above and below an alarm limit, reentering the acceptable range (non-alarm range) several times. During such fluctuation, the monitor integrates the number of SpO2 saturation points, both positive and negative, until either the Sat-Seconds limit is reached or the saturation level returns to within the normal range and remains there.

Sat-Seconds Display

When an SpO2 saturation value exceeds an alarm limit, a pie chart icon (circular graph) in the SpO2 parameter window begins to “fill” in a clockwise direction. As seconds pass and the value is compared against the alarm limits and the Sat-Seconds setting, the chart fills proportionately. When the pie chart icon is completely filled, indicating that the Sat-Seconds limit has been reached, an alarm sounds. When the SpO2 value is within the set limits, the Sat-Seconds pie chart icon “empties” in a counterclockwise direction.

Sat-Seconds “Safety Net”

The Sat-Seconds feature has a “safety net,” designed for patients whose SpO2 saturation is frequently outside the limits but does not remain outside the limits long enough for the Sat-Seconds limit to be reached. When three or more limit violations occur within 60 seconds, an alarm sounds even if the Sat-Seconds limit has not been reached.

Troubleshooting

SpO2 Messages

Below is a list of system status alarm messages which may be displayed in the SpO2 parameter window during monitoring. The messages displayed depend on the software installed in your monitoring system and the module you are using.

SpO2 messages will appear in abbreviated form in graph headers.

If you are unable to resume SpO2 monitoring, call service.

Artifact Detected

No SpO2 data is displayed due to signal interference. Check the patient and the probe.

Low Quality or Low Quality Signal

SpO2 data continues to be displayed, but the quality of the signal is questionable. Check the patient and the probe.

Poor Signal Quality Detected

The SpO2 signal is too low. No SpO2 data is displayed. This can be due to a low patient pulse, patient motion, or some other interference. Check the patient and the probe.

Probe or Module Malfunction

No SpO2 data is displayed due to an unrecognized or defective probe. Try the following solutions in order:

1. Change the probe.
2. Change the cable.
3. Change the module.
4. Call service.

Probe is Off the Patient

The disposable or reusable probe is off the patient. No SpO2 data is displayed. Check the probe.

Pulse Search

One of the following conditions is indicated:

- Defective or damaged probe,
- Incompatible probe,
- Probe is off the patient, or
- Detection of a repeatable pulse has ceased.

Check the probe and cable; reposition or replace as needed.

Clinical Questions

The following clinical questions are frequently asked about SpO2 monitoring. These may help in troubleshooting when monitoring SpO2.

Why does the monitor (pulse oximeter) sometimes read differently than an ABG?

Arterial Blood Gas analyzers calculate the O2 saturation based on normal values for pH, PaCO2, Hb, temperature, etc. (i.e., a normal oxyhemoglobin dissociation curve). Depending on the patient's physiologic and metabolic status, his/her curve and all his/her values may be shifted away from "normal." Thus the oximeter, which measures O2 saturation, may not agree with the ABG.

A CO-oximeter is an analyzer which also measures O2 saturation. The saturation of hemoglobin may be much closer to a pulse oximeter in these cases.

How does a pulse oximeter "read" the various types of hemoglobins?

All pulse oximeters utilize two wavelength absorption. This is because reduced hemoglobin (RHb) and oxyhemoglobin (HbO2) absorb these two wavelengths differently. The hemoglobin saturation is then figured from the measured amounts of the hemoglobins: (SpO2–HbO2)/(HbO2 + RHb). Carboxyhemoglobin (COHb) absorbs similarly to HbO2 and thus can raise the SpO2. Normal levels of COHb are 1-2%. Methemoglobin (MetHb) usually represents less than 1% total Hgb, but in cases such as some IV dyes, antibiotics, etc. this level may go up sharply. MetHb absorbs similarly to RHb, and thus could lower the SpO2 reading. Fetal Hb absorbs like adult Hb, thus the oximeter has the same accuracy with neonates and adults.

What effect can ambient light have on pulse oximetry monitoring?

Ambient light can have numerous effects. In the newborn, ICU bili lights can affect the readings of the oximeters. Outside light striking the probe detector can give poor waveform and inaccurate readings. Sunlight or bright indoor lights can have the same effect in other areas of the hospital using oximetry. Error messages of *The Probe is Off the Patient* or *Low Light, Check Probe*, etc. are possible. Shielding the probe with opaque tape, the posey wrap or other material can thus increase oximetry accuracy—verified by good waveform and signal strength.

What things can create inaccurate pulse oximeter readings?

Certain IV dyes, such as methylene blue, can affect the readings. Methylene blue will give falsely low readings due to excess absorption of the Red wavelength.

Nail polish, especially violets and blues, can also reduce the reading due to the same absorption. Removal of the polish is always recommended.

Long nails, and artificial or acrylic nails can interfere with good LED/ detector opposition through the tissue.

Patients with deeply pigmented skin may be tough to monitor, although finger pigmentation is usually less than the rest of the body.

Patients with sickle cell anemia undergoing a sickling crisis may have erroneous readings due to the absorption spectrum of HbS being different than for normal adult Hb.

Severely jaundiced patients have high levels of bilirubin in their blood. A product of bilirubin metabolism is CO and thus high levels of carboxyhemoglobin can be formed, causing the oximeter to read artificially high SpO2.

Patients with severe anemia can have low SpO2 readings.

Patients with heavy smoke inhalation can have transiently high CO levels and thus a high amount of Carboxyhemoglobin.

Certain antibiotics, such as the sulfas, can create high levels of methemoglobin. Methemoglobin is unable to bind O2 and will absorb light similarly to reduced hemoglobin, thus giving an artificially low SpO2.

What does electrosurgical interference look like and how can it be minimized?

Electrosurgical interference will be most obvious on the displayed waveform. It is a very spiky, erratic looking waveform caused by the electrosurgical unit's overwhelming interference in the OR. It can result in grossly inaccurate pulse oximeter parameters.

Electrosurgical interference can be minimized by:

1. Making sure the pulse oximeter probe is as far away from the return pad and operating site as possible.
2. Making sure the probe is not between the return pad and operating site.
3. Keeping the power cord and probe cable away from the power cord of the electrosurgical unit.
4. Plugging the electrosurgery unit into a separate set of outlets from the monitor.

NOTE: This section is not applicable to monitoring SpO2 with Tram x51M modules.

What does motion artifact look like, what problems can it cause, and how can it be corrected?

Motion artifact occurs with excessive motion of the probe, the cable leading to the probe or the cable/probe junction. In other words anything that causes any of these things to move, like the patient moving his/her hands, or the cable laying across the ventilator tubing and being moved with every cycle, can cause motion artifact. A non-arterial, often erratic looking waveform, and a pulse rate that does not coincide with the HR on the ECG will result.

The main problem motion artifact can cause is erroneous SpO2 readings.

Motion artifact can be reduced, if not eliminated, by selecting a “quieter” site on the patient. An ear probe if he or she refuses to keep his/her hands still, or an adhesive probe on the toe, an adhesive probe on the little finger for an adult, or on the sole of the foot in a newborn, can help greatly.

Cable movement can be reduced by applying the probe with the cable leading toward the patient, then taping the cable to the side of the hand or foot. In the case of the butterfly probe, the tape was designed to secure the cable to the finger.

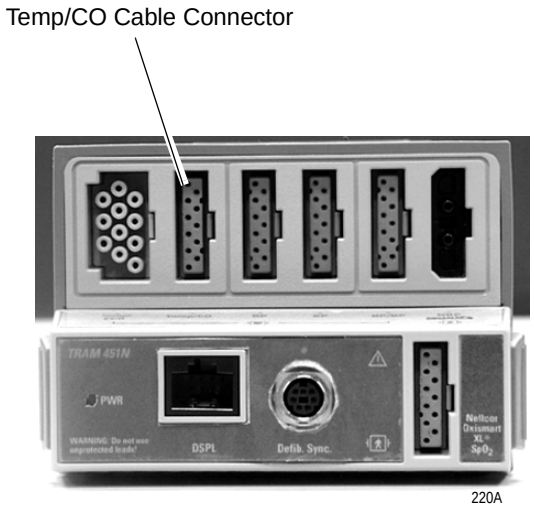
13 Cardiac Output Monitoring

For your notes

Introduction

The cardiac output (CO) program allows measurement of cardiac output by use of a thermodilution catheter with information processed by the Tram module. A numeric value and a real-time cardiac output waveform are displayed on the monitor's screen. The program allows you to perform multiple measurements and to delete those not wanted. All measurements are retained, but only four are included in the average value. The program will automatically average these and, when saved, enter the averaged values into cardiac calcs and trends.

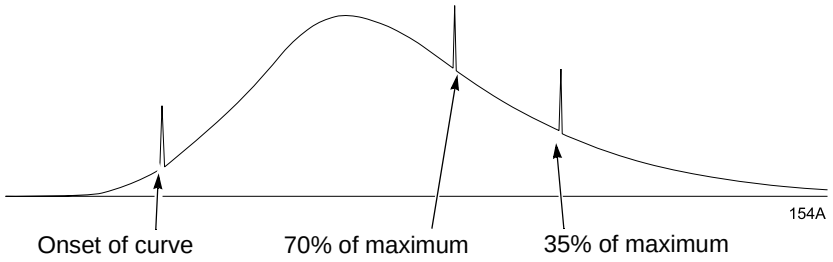
Connect the cardiac output patient cable to the TEMP/CO connector on the front of the module. Because the cardiac output connector on the Tram module is also used for temperature, cardiac output and temperature cannot be monitored at the same time using the Tram module. CO and temp monitoring can only be done at the same time if you have a separate dual temperature module.



Tram Module

Cardiac Output Waveform

The waveform, which appears on the screen after a CO injection, shows the drop in blood temperature as the injectate mixes with the blood. The peak of the waveform indicates the maximum difference in the patient's baseline blood temperature and the temperature of the injectate solution. As the mixture passes through the catheter and then out the pulmonary artery, the temperature difference decreases as indicated by the waveform returning to baseline. A spike is displayed at the onset of the curve, again at 70% and 35% of the maximum temperature difference. This curve is reproduced in reduced size in the trial curve review boxes.



Cardiac Output Washout Curve

Influencing Factors

Some of the factors which affect cardiac output are:

- the technique used in performing a cardiac output,
- temperature of injectate solution,
- volume of injectate solution,
- patient's baseline blood temperature,
- patient's inspiratory/expiratory cycle,
- placement of catheter with relation to proximity of lung field,
- the Swan-Ganz catheter itself,
- the patient's rhythm and hemodynamic status, and
- any other IV solutions which are rapidly infused while the cardiac output is being performed.

Technique

Following are some technique suggestions to obtain accurate cardiac output:

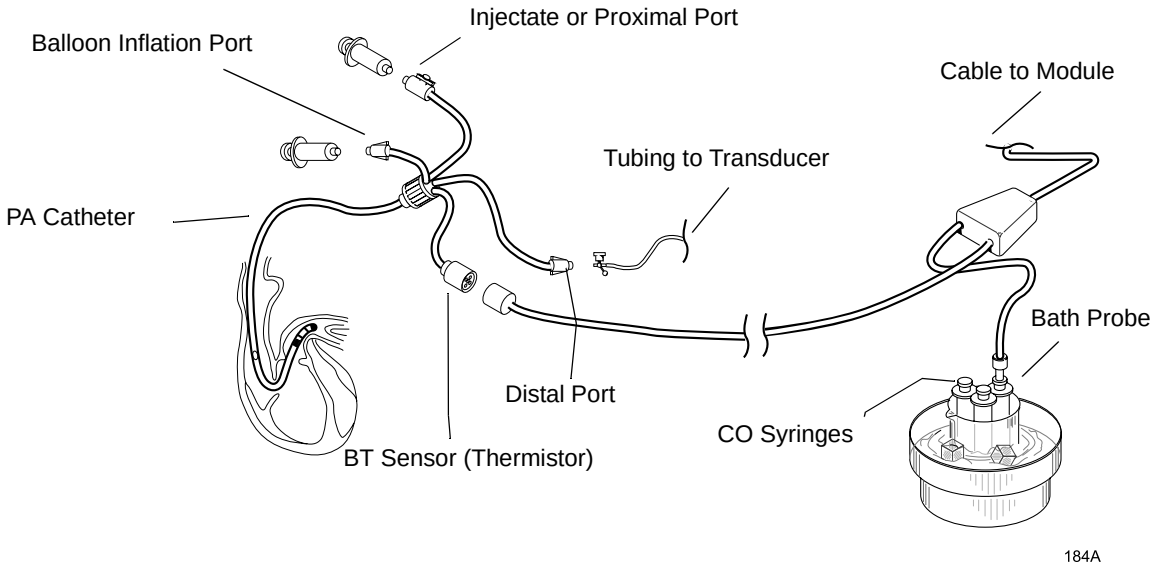
- Always hold syringe by plunger, not barrel.
- Injectate solution must be at least 4°C cooler than the patient's blood temperature.
- Inject solution rapidly and smoothly.
- Inject over 4 to 5 seconds.
- Inject at end expiration.
- Wait 1 minute between injections to allow baseline to stabilize.
- Use manual mode if unstable baseline blood temperature.

Checklist

1. Tram module is securely inserted in the Tram-rac housing.
2. Catheter is in place in the patient.
3. Cardiac output cable is connected to the module.
4. Depending on your setup choice, be sure:
   - In-line sensor is securely connected to tubing.
   - Bath probe is correctly sensing injectate temperature.
5. Cardiac output default settings are adjusted, if necessary. Follow detailed procedures within this chapter.

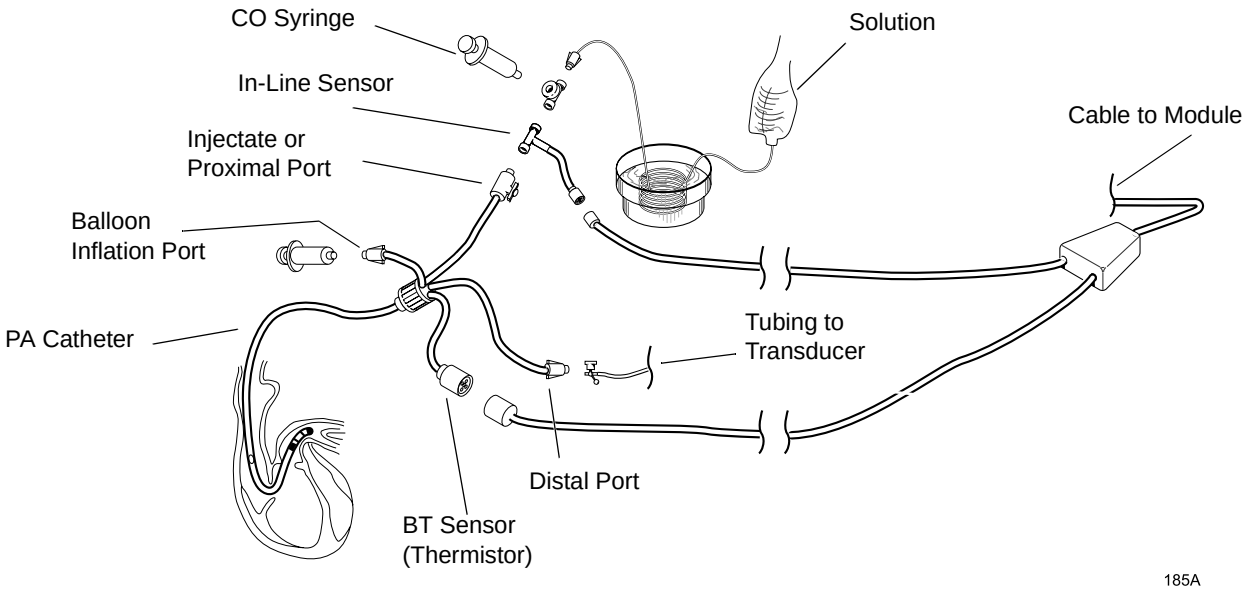
Sensor Setups

Bath Probe Setup



Cable Setup for Bath Probe Sensor

In-Line Setup



Cable Setup for In-Line Sensor

Cardiac Output Monitoring

The Solar 9500 Information monitor accepts cardiac output information from the Tram module.

Suggested Cardiac Output Procedure

Following is a summary of the entire cardiac output procedure. It is provided to give you an overall picture of the process. The rest of the chapter includes details and additional information that you should read. This suggested procedure can be a handy reference once you are familiar with the details.

1. Determine whether an in-line sensor or bath probe sensor is being used for cardiac output. Set up cables and prepare the patient accordingly. (Refer to setup diagrams on page 13-6.)
2. Select the CO parameter window on the monitor. The Cardiac Output procedure window opens. It can also be accessed by selecting *Cardiac Output* from the *Procedures* popup menu.
3. Select *Change Setup...* to verify that the settings are appropriate. The *CO Controls* window opens. For more information on the *CO Controls* window, refer to the Cardiac Output Controls Window section in this chapter.

   Adjustments can be made at this time using the menu options provided. Adjustments you may need to make include:

   a. Catheter type and size
   b. Computation constant
   c. Type of injectate temperature probe—in-line or bath probe
   d. Injectate volume
   e. Detection mode—Auto or Manual
   f. Units—Celsius or Fahrenheit

   When satisfied with the cardiac output settings, select *Close* to close the *CO Controls* window and return to the cardiac output procedure window.
4. Depending on the mode, you will see one of two messages: *Inject When Ready*, or *Press Manual Inject*. If the message reads *Inject When Ready*, proceed with the injection.

   If the message reads *Press Manual Inject*, you must select the *Manual Inject* button. Then watch for the *Inject Now!* message. Inject when you see the message.

   A few seconds after injecting, the washout curve begins to move across the screen and the message *Acquiring Washout Curve* is displayed. Then the message *Computing CO* is displayed.

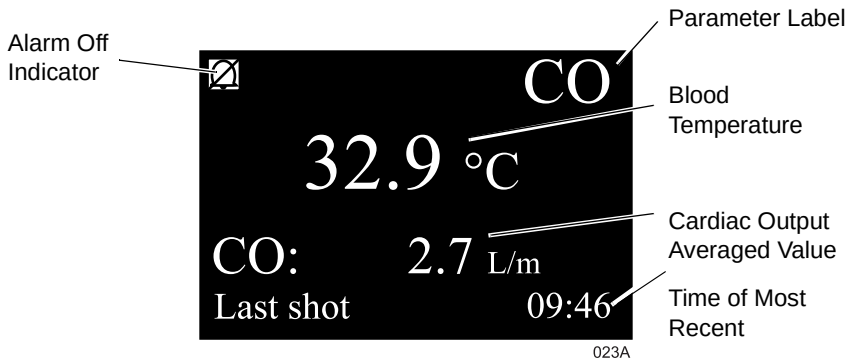
5. The curve will continue to move across the screen. Soon the message *CO Complete* is displayed, and the just-acquired CO value and curve are displayed in one of the four trial curve boxes. An average is displayed in the *CO Average* field.
6. Perform another injection when prompted. You can do as many injections as you want; however, the monitor only retains four. When a fifth injection is done, the first is deleted, etc.

   NOTE: The monitor actually retains all of the trials but only the four most recent accepted trials are used in the average. If you do a fifth injection, then reject one of the displayed trials, the first trial will again be displayed.
7. When all injections are done, select *Reject* for any of the displayed trials you do not want included in the average value. As you reject trials, the monitor will recalculate the average CO.
8. If you want a copy of the cardiac output trials information, select *Print* in the cardiac output procedure window.
9. When editing is complete, select *Store Average*. This clears all of the trial curves and values from the cardiac output procedure window.

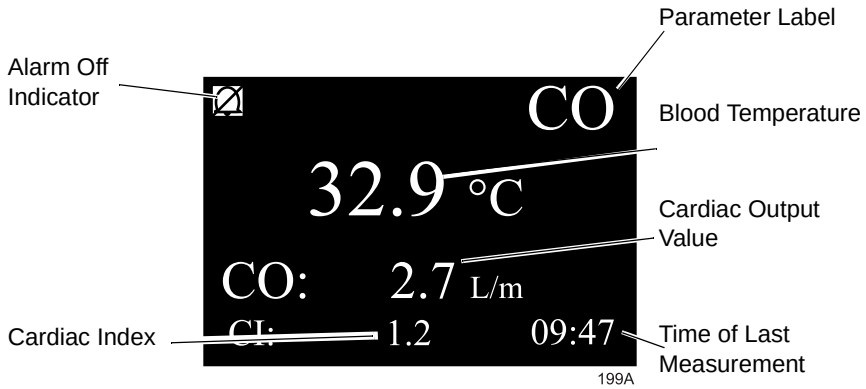
   Closing the window will also store the current average.

Cardiac Output Parameter Window

The CO parameter window displays blood temperature, the cardiac output value, and the time the last cardiac output measurement was taken.



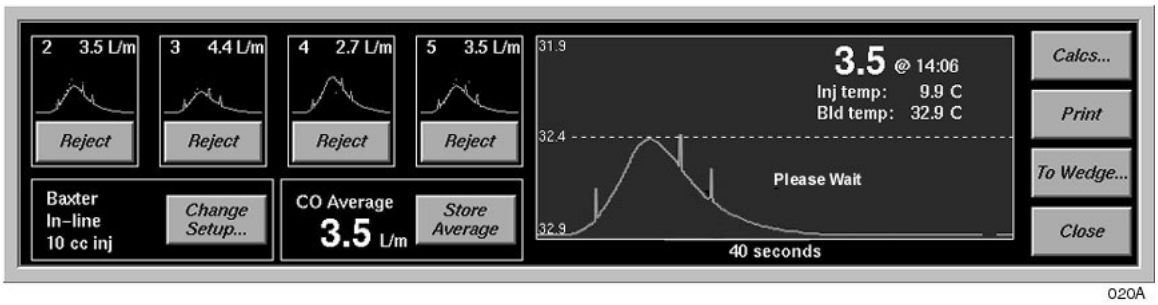
Cardiac Output Parameter Window (procedure in progress)



Cardiac Output Parameter Window (procedure complete)

Cardiac Output Procedure Window

Cardiac output measurements and analyses are performed and viewed primarily on the cardiac output procedure window. To access the cardiac output procedure window, select *Cardiac Output* from the *Procedures* popup menu, or touch or click in the CO parameter window.



Cardiac Output Procedure Window

Curve of the Current Trial

A large washout curve of the current trial occupies most of the cardiac output procedure window. The axes of the curve are labeled with temperature and time.

The cardiac output value, the time of the trial, the injection temperature, and the blood temperature are displayed over this curve. Any cardiac output messages also appear over this curve.

Trial Curve Review Boxes

The cardiac output procedure window contains curves of four trials in review boxes, each with a *Reject* button to accept or reject the trial.

If a *Reject* button is selected, a red X is placed over the curve, and the button changes to *Accept*. If *Accept* is then selected, the red X is cleared, and the trial will be included in the average saved to cardiac calculations. If not, the rejected trial will be removed from the display and replaced with newer trial information.

You may perform as many trials as you wish, but only the four CO trials displayed are included as part of the average.

Current Setup Information

There is a current setup information box in the lower left corner of the cardiac output procedure window. Information regarding the catheter type, injection type, and injection volume is shown here.

Change Setup…

To access a control screen to change the current setup, select the *Change Setup…* button. This opens the *CO Controls* window. Refer to the Cardiac Output Controls Window section in this chapter.

Store Average

The average of all of the currently accepted cardiac output trials is displayed in a l/m (liters/minute) format. To store the current average, select the *Store Average* button.

When *Store Average* is selected, the review trials are cleared from the display.

Other Options

The cardiac output procedure window also offers buttons which open/activate other related areas/functions. These buttons are:

Calcs…

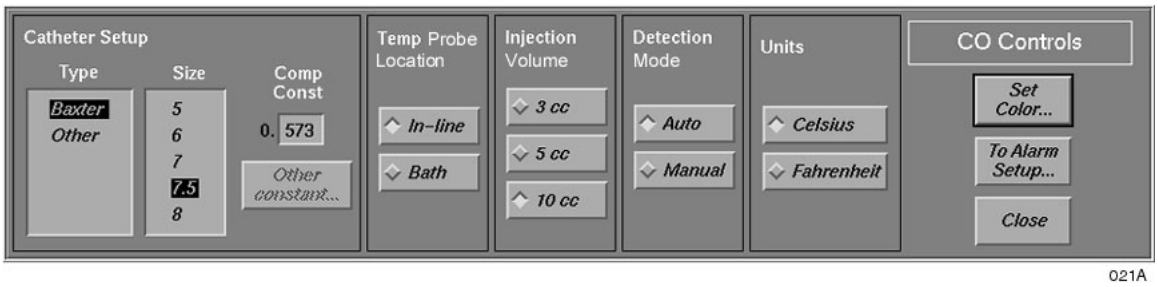
Print

To Wedge…

Close

Cardiac Output Controls Window

To open the *CO Controls* window, select *Change Setup*... from the cardiac output procedure window.



***CO Controls* Window**

NOTE: It is recommended that any changes to the *CO Controls* window be made before an injection is begun. If you make changes after one or more cardiac output trials have been done, the trials will be deleted. This does not affect any calculations already saved.

Catheter Setup

The *Catheter Setup* controls allow you to determine the computation constant for the catheter used.

Type

The *CO Controls* window defaults to a Baxter catheter, with a known computation constant.

If you are using a different type of catheter, select *Other*. The *Other constant*... button becomes active. Select *Other constant*... to bring up a numeric keypad for entering the computation constant found in the literature for the catheter you are using.

Size

This option allows you to select the size of the catheter being used. Changing this option will cause the monitor to calculate a new computation constant when the next trial is done.

Comp Const

If the catheter type selected is *Baxter*, and after the size has been specified, the computation constant value will appear in the *Comp Const* window after the trial is complete (the computation constant information comes from the Tram module).

If the catheter type selected is *Other*, and after the size has been specified, select *Other constant*... to bring up a numeric keypad for entering the new computation constant.

Temp probe location

The temperature of the injectate is determined by the type of sensor used—in-line or bath probe. It is important to have the monitor set for the type of sensor used to assure a valid CO reading. Changing this option will cause the monitor to calculate a new computation constant when the next trial is done.

Choices for temperature probe location are *In-line* and *Bath*. The default temperature probe location is *In-line*.

Injection volume

If you want to change the injectate volume, follow the procedure below. When using a Baxter or other catheter setup, changing this option will cause the monitor to calculate a new computation constant when the next trial is done.

Choices for injection volume are *3 cc*, 5 cc, and *10 cc*. The default injection volume is *10 cc*.

Detection mode

Choices for detection mode are *Auto* and *Manual*. The system defaults to *Auto* mode.

When auto mode is on, the monitor automatically searches for a stable baseline temperature by averaging approximately 8.5 seconds of the patient's blood temperature. Once a stable baseline is established, the message *Inject When Ready* is displayed, and you can proceed.

Units

Choices for units are *Celsius* and *Fahrenheit*. The system defaults to *Celsius*.

CO Controls

The *CO Controls* also offer buttons which open/activate other cardiac output related areas/functions. These are:

Set Colors…

To Alarm Setup…

Close

Cardiac Calcs

Introduction

The cardiac calculations program displays important hemodynamic parameter values. These parameters are separated into two classifications: monitored parameters and calculated parameters. An active field is provided to change or enter a monitored parameter value.

Monitored Parameters

The monitored parameter values are obtained from available monitored patient data. Only two values must be entered manually: weight and height (these values can also be entered in the *Patient Information* window, available within the *Patient Data* popup menu).

The chart below shows the monitored parameters, the labels used to identify these parameters on the screen, and the units of measure.

Monitored Parameters		
Parameter	**Label**	**Units**
Cardiac Output	CO	l/min
Heart Rate	HR	BPM
Mean Arterial Pressure*	MAP	mmHg
Central Venous Pressure	CVP	mmHg
Pulmonary Artery Mean	PAM	mmHg
Pulmonary Artery Wedge	PAW	mmHg
Height	Ht	cm or inches
Weight	Wt	kg or lbs

* Mean arterial pressure is only entered from a site labeled ART not FEM or UAC.

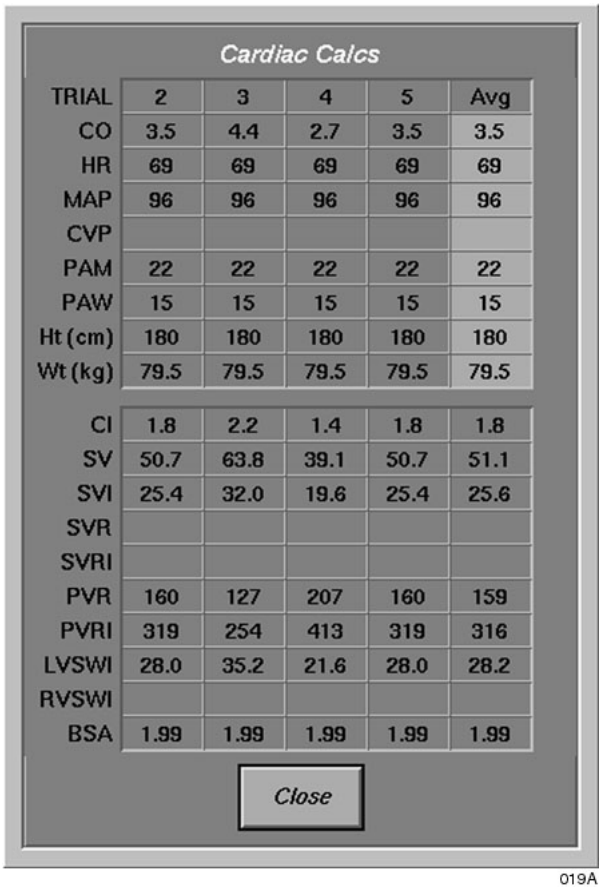
Calculated Parameters

The calculated parameter values are figured automatically. The chart below shows the calculated parameters, the labels used to identify these parameters on the screen, the units of measure, and the formulas used.

Calculated Parameters			
Parameter	**Label**	**Unit**	**Formula**
Cardiac Index	CI	$L/min/m^2$	CO/BSA
Stroke Volume	SV	ml/beat	CO/HR • 1000
Stroke Volume Index	SVI	$ml/beat/m^2$	CI/HR • 1000
Systemic Vascular Resistance	SVR	$dyn \cdot sec \cdot cm^{-5}$	[(MAP–CVP) • 79.92]/CO
Systemic Vascular Resistance Index	SVRI	$dyn \cdot sec \cdot cm^{-5} \cdot m^2$	SVR • BSA
Pulmonary Vascular Resistance	PVR	$dyn \cdot sec \cdot cm^{-5}$	[(PAM–PAW) • 79.92]/CO
Pulmonary Vascular Resistance Index	PVRI	$dyn \cdot sec \cdot cm^{-5} \cdot m^2$	PVR • BSA
Left Ventricular Stroke Work Index	LVSWI	$g \cdot m/m^2$	[SV • (MAP–PAW) • 0.0136]/BSA
Right Ventricular Stroke Work Index	RVSWI	$g \cdot m/m^2$	[SV • (PAM–CVP) • 0.0136]/BSA
Body Surface Area	BSA	m^2	$HT^{0.725} \cdot WT^{0.425} \cdot 0.007184$

Cardiac Calcs Table

The *Cardiac Calcs* table can be accessed by selecting *Calcs...* in the cardiac output procedure window.



***Cardiac Calcs* Table**

The cardiac calculations are stored from the cardiac output procedure window. A table will be displayed with the measured and calculated values for each trial and a column with the averaged data.

The *Avg* (Average) column for measured values has a lighter color, which indicates that you can touch the table cell to edit the data. When a cell is accessed for editing, a numeric keyboard opens for entering new values.

After a new value has been entered, the calculations are updated with the new data. Select *Store CO* or close the cardiac output application to store the contents of the *Avg* column in trends for review. For more information on trended cardiac calculations, refer to Cardiac Calcs in Chapter 6, Patient Data.

Troubleshooting

Procedural Prompts/Messages

During the injection procedure you may see some of the following prompts/messages displayed on the screen. These have been listed alphabetically.

Acquiring Washout Curve
An injection has been detected.

CO Complete
The numeric value of the CO has been calculated and displayed on the screen.

Computing CO
CO waveform has been displayed and now the monitor is preparing the numeric results.

Inject Now!
The Manual Inject option has been selected. Make your injection immediately.

Inject When Ready
The Auto Mode option has been selected and the monitor has sensed a stable baseline temperature. Make your injection when ready.

Please Wait
The monitor is searching for a stable baseline temperature.

Press Manual Inject (manual mode only)
The *Manual* mode has been selected, and the monitor is ready for a manual injection. Press *Manual Inject* just before injecting.

Error Messages

CO Too Low To Be Displayed
The calculated cardiac output is less than 0.2 l/m.

CO Too High To Be Displayed
The calculated cardiac output is greater than 20 l/m.

IT Too High
There is less than a 4°C difference between blood temperature and injectate temperature.

No CO Due to BT Sensor Fail
The blood temperature sensor failed during a measurement.

No CO Due to IT Sensor fail
The injectate temperature sensor failed during a measurement.

Sensor
A cable may be loose or there is a hardware failure.

Unstable BT Detected
There is too much baseline drift to perform a measurement.

Common Problems

Problem: Inaccurate Cardiac Output Values

Solutions:

Technique—the technique used in performing a cardiac output is important to understand since this is a major influencing factor in obtaining accurate cardiac output values.

1. If room temperature solution is used, be sure the bag is not in a heated area in the room and is not touching other solutions or equipment. This is important so the solution temperature will not be different than the room air temperature sensed through the bath or in-line sensor. A temperature difference could give an inaccurate reading.
2. When doing an injection, always hold the syringe by the plunger and not by the barrel. The temperature of the solution increases at a slower rate if the barrel is not held in the palm of the hand and, therefore, reduces the amount of error in a cardiac output value.

NOTE: When In-Line is being used, along with iced injectate, the initial temperature displayed will be the room temperature. However, when the solution is injected, the temperature displayed will decrease.

3. It is recommended to inject rapidly and smoothly into the proximal port of the Swan-Ganz catheter, usually within 4 to 5 seconds.
4. Allow at least 1 to 1-1/2 minutes between injections to allow the baseline to stabilize.
5. It is also recommended to inject at the patient's end expiration. This helps to reduce any respiratory noise and therefore lessen error.
6. A minimum temperature difference of 4°C is recommended between the patient temperature and solution temperature.

Respiration—the patient's inspiratory/expiratory cycle and placement of the catheter affects the cardiac output value. Whenever the patient inhales and exhales, the thermistor at the tip of the catheter senses a change in the patient's blood temperature. Therefore, placement of the catheter with relationship to proximity of the lung fields affects the baseline. During inspiration, the patient's blood temperature decreases and during expiration it increases.

If there is a significant amount of respiratory noise on the patient's baseline, the monitor may try to calculate a cardiac output even if no injection was performed. This is because the monitor does not differentiate between breaths and injections. It looks for a change in baseline temperature.

1. If patient is alert, have him/her exhale and hold for injection.
2. Check catheter placement.

Baseline blood temperature—as little as a half a degree Celsius change in blood temperature, due to respiratory noise, may cause a CO value to be displayed when an injection has not been performed. Using AUTO mode allows the monitor to look for a stable baseline before allowing an injection.

Swan-Ganz catheter—the catheter itself may be damaged (e.g., defective thermistor or defective tubing).

Hemodynamics—the patient's rhythm can affect the cardiac output value. If cardiac output trials are being done at a time when the patient has dysrhythmias, you may notice a discrepancy in the cardiac output values.

Rapid IV solutions—any rapid IV solution which is infusing at the time when the solution is injected can alter the cardiac output value. Maintain a constant rate, or if possible, stop the solution 30 seconds before the CO injection and then restart the infusion after the cardiac output is calculated.

IT temp fluctuation—if the IT temp is fluctuating, check IT cable connection.

Problem: Cardiac Output Value Lower than Expected

Solutions:

1. Decrease the volume injected.
2. Increase the temperature of the injectate.

NOTE: Cardiac output must be computed within 20 seconds. Decreasing the volume and increasing the temperature will give you a smaller differential change and should increase the chance of computing a cardiac output within the 20-second period.

Problem: Cardiac Output Value Higher than Expected

Solution:

1. Increase the volume injected.
2. Decrease the temperature of the injectate.

NOTE: Cardiac output must be computed within 20 seconds. Increasing the volume and decreasing the temperature will give you a greater differential change.

For your notes

14 Respiration Monitoring

For your notes

Introduction

Respiration monitoring can be done with any Tram module and the ECG cable. Refer to the ECG chapter for patient preparation and electrode placement.

This chapter gives guidelines for adjusting respiration setup, and problem solving. The illustration below show the locations of the respiration connectors on the Tram module.

Tram Module

NOTE: When monitoring CO2, a respiration rate is always displayed in the CO2 parameter window. If monitoring CO2, you may not want to monitor respiration by the impedance method as described in this chapter. Refer to the CO2 chapter for more details.

NOTE: The signal input is a high-insulation port and it is defibrillator-proof ( ).

The insulated input ensures patient safety and protects the device during defibrillation and electrosurgery.

NOTE: Respiration monitoring is not adversely affected by the use of an ESU ECG filter.

General Information

NOTE: The Solar 9500 Information Monitor does not use the term “Apnea.” Instead, its alarm message uses the phrase “No breath.”

WARNINGS

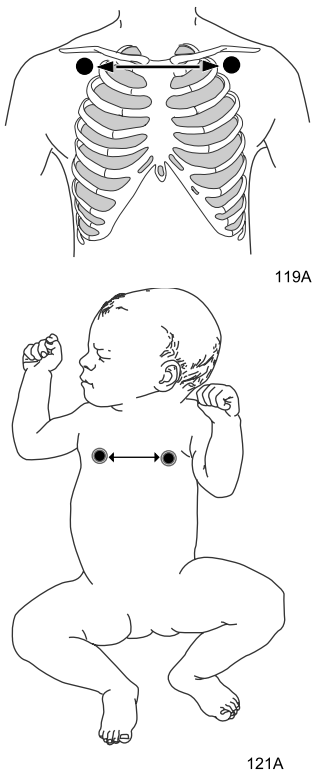
APNEA EVENTS — The monitor may not detect all episodes of inadequate breathing, nor does it distinguish between central, obstructive and mixed apnea events.

The safety and effectiveness of this device in the detection of apnea, particularly in apnea of the premature or apnea of infant patients have not been established.

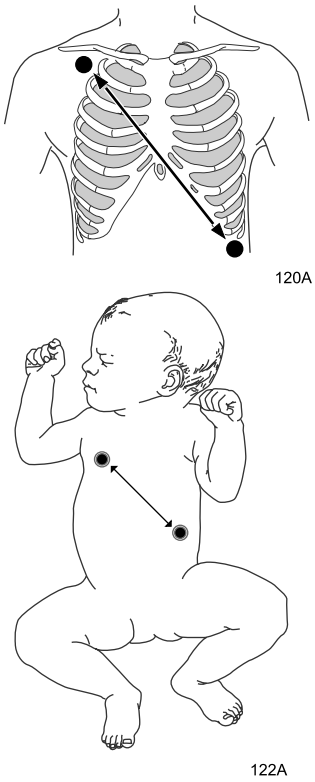
ELECTRODE CONFIGURATION — impedance respiration monitoring is not reliable when ECG electrodes are placed on the limbs.

Respiration is detected by measuring thoracic impedance. When respiration is monitored a small AC signal is applied through ECG lead I or ECG lead II. This AC signal appears between the RA and LA electrodes or the RA and LL electrodes, depending on the selected ECG lead. The lead selected is dependent on the type of “breather” the patient is. (See the figures below.)

NOTE: The figures below are used to show the relationship between breathing and ECG lead. They do not represent an electrode configuration.



ECG Lead I for Upper Chest Breather



ECG Lead II for Abdominal Breather

When starting respiration monitoring, the monitor "learns" the patient's respiration pattern. Eight breaths are averaged and the average amplitude of the respiration waveform is found. Detection sensitivity is automatically set at 40% of the average amplitude.

NOTE: The message *Learning* is displayed in the Resp parameter window during this process.

Markers displayed on the waveform show this 40% detection range. One marker is at inspiration, the other at expiration. The detection sensitivity can be manually adjusted by using the *Breath Detection Sensitivity* option in the *RESP Controls* window.

The waveform size is also set automatically during the learning process, but may be adjusted if necessary.

NOTE: Respiration detection is not dependent on the size of the waveform. Size is for visual purposes only.

Even though the same electrodes are used for ECG and respiration monitoring, it is possible to get a lead fail message for respiration without one for ECG. The impedance may be too high for respiration detection, but the electrode is still good for ECG. (Refer to Smart-Lead Fail in Chapter 9, ECG Monitoring.)

Checklist

Since respiration monitoring is so closely linked with ECG monitoring, patient preparation and electrode placement are important. Please refer to the ECG Monitoring chapter for guidelines.

1. The module is securely inserted in the Tram-rac housing.
2. Electrodes have been placed on the patient following proper skin preparation.
3. Leadwires are attached to electrodes on the patient.
4. Leadwires are connected to the patient cable and the patient cable is connected to the module.
5. Respiration setup is adjusted, if necessary. Follow detailed procedures within this chapter.

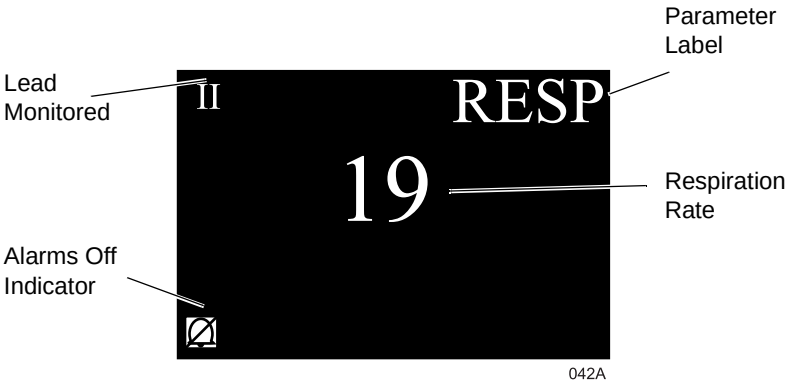
Respiration Information

Respiration Waveform

When respiration monitoring is on, you can configure the waveform window to display a respiration waveform. Refer to “Configuring Waveform Windows” in Chapter 1, The Basics.

The waveform label includes the ECG lead used to derive the respiration waveform.

Respiration Parameter Window

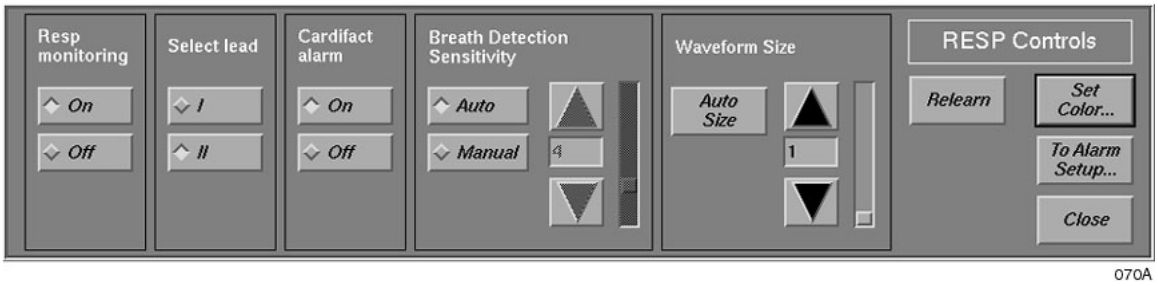


Respiration Parameter Window

The parameter window displays the current respiration rate and the ECG lead used to monitor respiration.

Resp Controls Window

To display the *RESP Controls* window, select *RESP...* from the *Respiratory* popup menu. The *RESP Controls* window can also be opened by touching or clicking on the RESP parameter window.



***RESP Controls* Window**

Resp Monitoring

The *Resp monitoring* controls turn respiration monitoring on and off. A light is illuminated next to the label of the active option.

Lead

You have two choices for the respiration lead—lead I and lead II. This menu option, when selected, automatically switches the monitored lead for respiration. The label of the lead currently being monitored (I or II) appears in the menu option, and in the upper left corner of the Resp parameter window.

Changing leads automatically starts the relearn process.

NOTE: If you are monitoring with a fixed-lead 3-lead cable, respiration can only be obtained from the lead for which the cable is manufactured. For example, if your cable is a fixed lead II cable, you will see a "*Lead I Fail*" message in the Resp parameter window if you try to change the respiration lead.

The default lead for respiration monitoring is Lead II.

Cardifact Alarm

The cardiac artifact (cardifact) alarm alerts you to the fact that the respiration rate is within 5% of the heart rate (over 30 consecutive breaths). If this happens, the respiration program may be counting heart beat artifact as respiration. The cardiac artifact alarm is an advisory alarm — *Cardifact?* is displayed in the RESP parameter window, and an advisory alarm sounds.

There is no adjustable limit for this alarm, but you can turn it off and on. The default setting is *Off*.

WARNING
If the cardifact alarm is turned off, "no breath" events may not be detected.

Breath Detection Sensitivity

During the learning process, the monitor automatically sets the detection sensitivity at 40% of the average amplitude. Markers are displayed on the waveform showing the detection points at inspiration and expiration. Options are *Auto* or *Manual*. A light is illuminated next to the label of the active option. You may need to change the detection sensitivity because of varying amplitudes or artifact.

To manually change the breath detection sensitivity, select the *Manual* option, and use the up and down arrows until the inspired and expired detection markers on the waveform are properly positioned on all breaths. The lower the percentage, the greater the detection sensitivity.

The default breath detection sensitivity setting is *Auto*.

NOTE: The breath detection sensitivity value displayed in the *RESP Controls* window is shown as a factor of ten. For example, if breath detection sensitivity is set to 40%, the displayed value is 4.

Waveform Size

NOTE: The size of the waveform has no effect on the detection capability of the program.

During the learning process, the displayed waveform is automatically sized to fit a predetermined area of the screen. During monitoring, the size may have been changed manually (see below). Select the *Auto Size* option to automatically resize the waveform to fit the predetermined area. This is a direct action menu option.

To manually change the size of the respiration waveform, use the up and down arrows until the value displayed in the window is satisfactory.

RESP Controls

The *RESP Controls* window also offers buttons which open/activate other related areas/functions. These buttons are:

Relearn

Set Color…

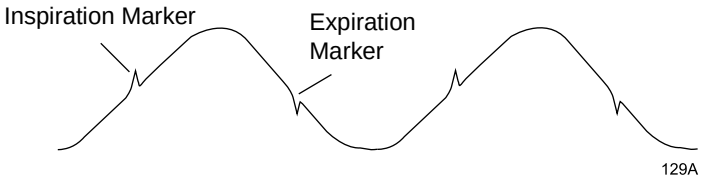
To Alarm Setup…

Close

Troubleshooting

Respiratory Waveform

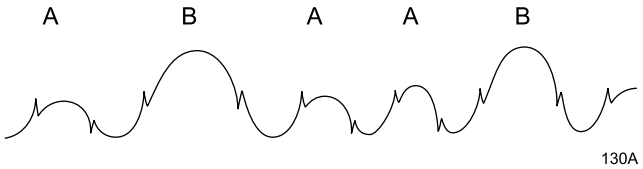
Illustrated below is a respiratory waveform which is regular and even. The inspiration and expiration markers are identified.



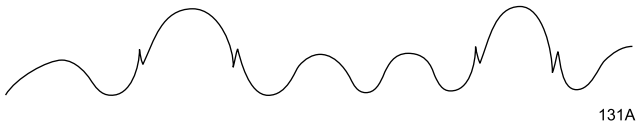
Regular and Even

Cardiac Artifact

In cases where there is cardiac artifact, if the detection sensitivity percentage is set too low, the artifact will be detected as breaths. Increase the detection sensitivity percentage until the markers correctly identify each inspiration and expiration. See the markers in the figures below (A = artifact, B = breath).



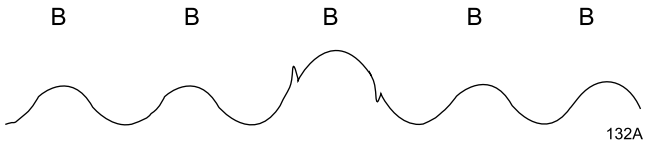
Incorrect Detection



Correct Detection

Varying Amplitudes

Some waveforms may show a combination of shallow and deep breaths. If the detection sensitivity percentage is set too high, the shallow breaths will not be detected. Decrease the detection sensitivity percentage until the markers correctly identify each inspiration and expiration. See the markers in the figures below (B = breath).



Incorrect Detection

Correct Detection

Messages

Below is a list of all the messages which may be displayed in the Resp parameter window during respiration monitoring. What each of these messages mean as well as action to take is included.

Learning

The monitor takes approximately 8 breaths to learn the patient's respiration pattern before displaying a respiration value. Learning automatically occurs whenever respiration is turned on and when the lead from which respiration is determined is switched. Additionally, you can initiate a relearn manually.

No Breath

CHECK THE PATIENT. This is an alarm condition which requires action. Breathing has not been detected for a predetermined period of seconds. If necessary, the *No Breath* limit can be changed.

Cardifact?

CHECK THE PATIENT. This is an alarm condition which requires action. The monitor is unable to successfully determine respiration. If it is determined that patient condition is not the cause, it may be necessary to re-prep the patient's skin and change the electrodes to resume monitoring of respiration.

Lead I Fail or Lead II Fail

CHECK THE PATIENT. This is an alarm condition which requires action. The lead monitoring respiration has failed. You can manually switch respiration detection to the other lead, or it may be necessary to re-prep the patient's skin and change the electrodes.

Leads Fail

CHECK THE PATIENT. This is an alarm condition which requires action. It may be necessary to re-prep the patient's skin and change the electrodes.

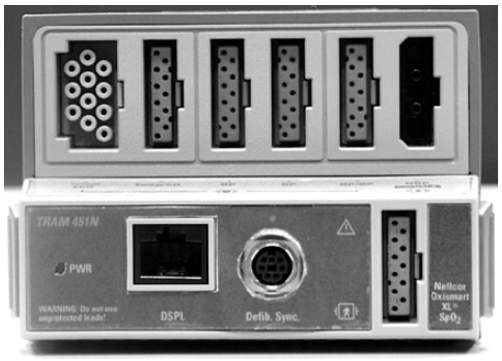
For your notes

15 Temperature Monitoring

For your notes

Introduction

Multiple temperature sites can be monitored with any of the Tram modules, with the separate GE Medical Systems *Information Technologies* dual temp module, or with the blood pressure/dual temp module. Because the temperature connector on the Tram module is also used for cardiac output, you cannot monitor temperature and cardiac output at the same time with only the Tram module.

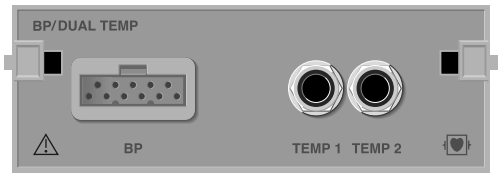


220A

Tram Module

152A

Dual Temperature Module



151A

BP/Dual Temperature Module

NOTE: The signal input is a high-insulation port and it is defibrillator-proof ( ).

The insulated input ensures patient safety and protects the device during defibrillation and electrosurgery.

Checklist

1. The module is securely inserted in the Tram-rac housing.
2. The temperature probe(s) is correctly positioned on the patient. (Follow appropriate medical procedures.)
3. The dual temperature cable switch is turned to 400 or 700 depending on the type of probes used.
4. Temperature cable is attached to the module.
5. Temperature setup is adjusted, if necessary. Follow the procedures within this chapter.

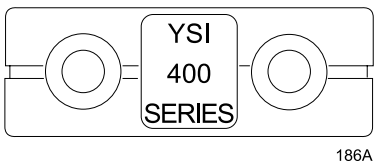
Temperature Monitoring Features

Temperature Information

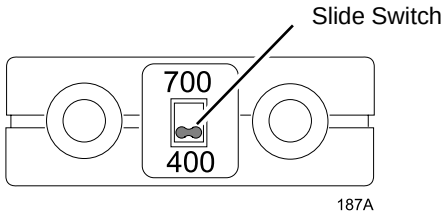
Temperature monitoring provides numerical information only—no waveform. As with other parameters, numerics are displayed in the temperature parameter window. As with invasive pressures, the temperature parameter label has a number that corresponds to a slot in the Tram-rac housing where the cable is connected. The parameter window displays the current temperature values with the unit of measurement.

You can monitor a patient's temperature at multiple sites. Both internal and external temperature sensors may be used. The module calculates the monitored temperatures and displays their values in the temperature parameter window. The temperature sites are identified in the parameter window as *TMP1* and *TMP6*, and *TMP8*.

The Tram module is compatible with both YSI series 400 and 700 probes. If you are using the dual temperature cable, you must select 400 or 700 (depending on the type of probe) for correct operation. (See the figure below.) The switch is located on the end of the cable.



YSI 400 Series Temperature Cable

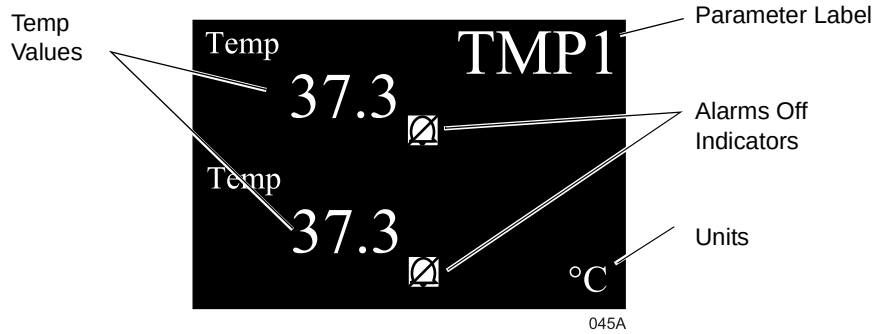


Dual Temperature Cable Selection Switch

The temperature monitoring features are found in the *TEMP Controls* window.

Temperature Parameter Window

The temperature parameter window displays temperature values and units.

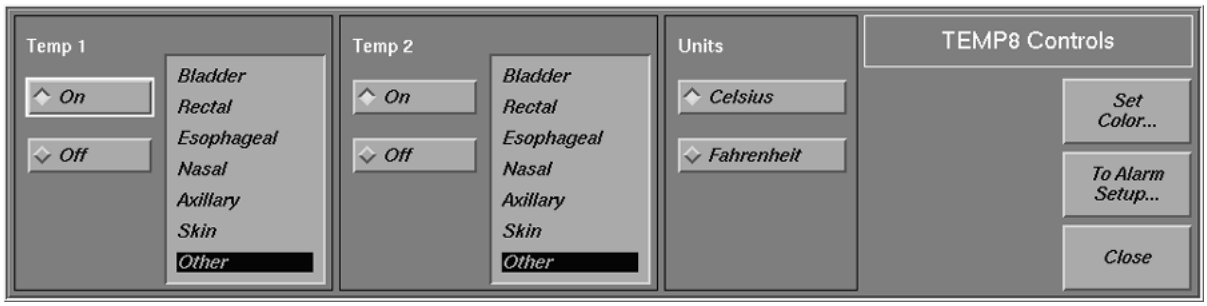


Temperature Parameter Window

Temperature Monitoring

Temperature Controls Window

To access the *TEMP Controls* window, select the appropriate temperature site (e.g., *Temp1*...) from the *Temps* popup list, or touch or click in the TMP parameter window.



***TEMP Controls* Window**

The temperature control screen comprises two temperature channels, units, and temp controls.

Temperature Channels

To enable a temperature channel, select *On* and choose a temperature location from the choice list. To disable a temperature channel, select *Off*.

NOTE: Selecting *Other* from the temperature location choice list labels the temp "*TMP1*" or "*TMP2.*"

Units

Temperature units options are *Celsius* or *Fahrenheit*. An indicator light is illuminated next to the active units selection.

TEMP Controls

The *TEMP Controls* also offer buttons which open/activate other temperature-related areas/functions. These buttons are:

Set Color…

To Alarm Setup…

Close

Troubleshooting

Messages

If you experience some problems with temperature monitoring, one of the following messages may be displayed in the TMP parameter window:

Calibration Check Failure

There is a 0.1°C deviation between the temperature value and the internal calibration. No temperature value will be displayed. Service on the module is required.

Calibration Failure

There is a 1°C deviation between the temperature value sensed and the internal calibration. No temperature value will be displayed. Service on the module is required.

Sensor Fail

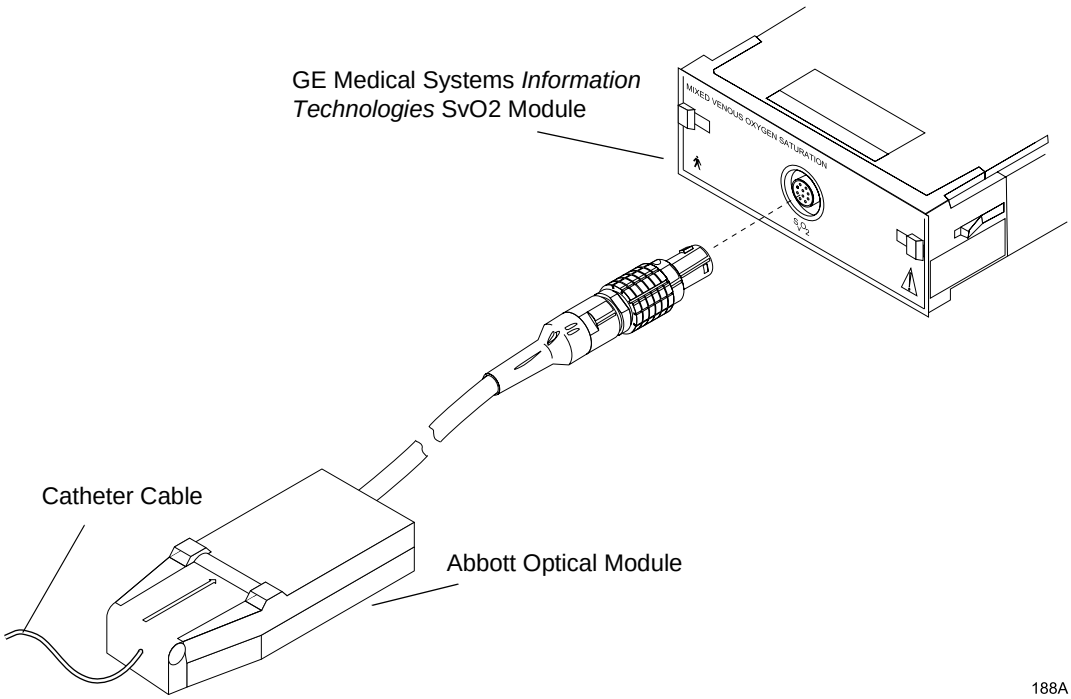
No sensor is detected. Replace the failed sensor. If no sensor is present, turn the temperature site *Off* to clear the message.

16 SvO2 Monitoring

For your notes

Introduction

Mixed venous oxygen saturation (SvO2) monitoring is done with the GE Medical Systems *Information Technologies* Mixed Venous Oxygen Saturation (SvO2) module. The module is used in conjunction with Abbott's Oximetrix catheter and Optical module to provide mixed venous oxygen saturation values.



GE Medical Systems *Information Technologies* SvO2 Module and Abbott Optical Module

NOTE: The signal input is isolated, but it is not defibrillator-proof ( ).

A type of multilumen, flow-directed, pulmonary arterial catheter connects to the Abbott Optical module which, in turn, connects to the GE Medical Systems *Information Technologies* SvO2 module. The catheter contains fiberoptic strands that pass three wavelengths of light directly into the blood in the pulmonary artery and transmit the reflected light back. The measurement of oxygen saturation follows the same principle as noninvasive pulse oximetry (SpO2) measurement.

SvO2 measures the percentage of hemoglobin in the venous blood carrying oxygen. When blood passes through the lungs, oxygen combines with almost all hemoglobin molecules resulting in a saturation of approximately 100% in a normal person. When the blood passes through the tissues, a fraction of the hemoglobin molecules release their oxygen to meet the metabolic needs of the cells. The normal percentage of hemoglobin retaining oxygen in venous blood is 60–80%. This value varies with cardiac output, oxygen consumption of the tissues, the amount of normally functioning hemoglobin, and tissue oxygen consumption.

Checklist

1. The SvO2 module is securely inserted in the Tram-rac housing.
2. The Abbott optical module's cable is connected to the GE Medical Systems *Information Technologies* SvO2 module.
3. The Abbott Oximetrix catheter is connected to the Abbott optical module.
4. A calibration procedure is done before the catheter is either inserted in the patient or calibrated to venous blood after insertion. Refer to "SvO2 Calibration" in this chapter.
5. The Abbott mixed venous oxygen saturation catheter is inserted in the patient. Follow all guidelines specified in the Abbott literature.
6. Any other necessary calibration procedures are done. Refer to details in this chapter.

Signal and Data Validity

Signal Strength Indicator

It is extremely important to determine that the signal coming from the Abbott catheter is adequate for reliable saturation readings. To assist in making this determination, the monitor displays a signal strength indicator.

The signal strength indicator is displayed in the SvO2 parameter window, below the SvO2 value. This indicator consists of zero, one, two, or three asterisks. The clinical implications of this indicator are:

- Three Asterisks Condition: Optimum light intensity.
- Two Asterisks Condition: Adequate light intensity for reliable saturation value.
- One Asterisk Condition: Inadequate light intensity for a reliable saturation value. A saturation value is displayed under these conditions but it may not be reliable. The clinician should exercise caution and rectify the light intensity problem as soon as possible.
- Zero Asterisks Condition: Inadequate light for any calculation.

SvO2 Calibration

There are three different calibration procedures available to the user: Preinsertion Calibration, Light Intensity Calibration, and Calibrate to Venous Blood Gas.

Before valid data can be obtained, either the blood gas calibration or the preinsertion calibration must be performed. If the preinsertion calibration is performed, the light intensity calibration must also be performed once the catheter is properly positioned in the patient. The light intensity calibration is not needed if the venous blood gas calibration is performed, since it is done automatically in the venous blood gas calibration.

Preinsertion Calibration

The SvO2 module has been programmed for use with a standard optical reference that is packaged with the catheter. Each new catheter/optical module should be calibrated to this reference before placing the catheter in the patient to insure proper operation of the system. After the preinsertion calibration procedure described here is completed, the system will be ready to use. If the catheter is placed in a patient without calibrating the system, a Calibrate to Venous Blood Gas calibration must be performed.

To perform a preinsertion calibration, follow this procedure:

1. Connect all cables but leave the patient end of the catheter in the package.
2. With the catheter still in the package, select the *Preinsertion calibration* option from the *SvO2 Controls* window.
3. The following message will appear in the *Cal messages* window:

   Calibration takes up to 60 seconds

4. When the preinsertion calibration is complete, one of two messages will be displayed:

   Do light intensity calibration

   A successful preinsertion calibration has been performed; proceed to the light intensity calibration.

   NOTE: After a preinsertion calibration there will be no light intensity alarms until a light intensity calibration has been performed.

   Preinsertion calibration failure

   Calibration was unsuccessful. Verify that the catheter has been properly connected to the optical module and repeat the preinsertion calibration procedure. If the failure message still appears, use another catheter. Continued failure may indicate that the Abbott optical module is defective.

Light Intensity Calibration

The light intensity calibration calibrates the SvO2 module to the light intensity signal being received from the patient. A light intensity calibration must be performed after proper positioning is achieved following catheter insertion. (The catheter should be positioned such that all three asterisks appear in the SvO2 parameter window.) In addition, if any significant change in light intensity occurs that cannot be corrected (such as might happen when the catheter fiberoptics are damaged), a light intensity calibration is necessary.

Follow this procedure:

1. Select the *Light intensity calibration* option from the *SvO2 control* window. The calibration takes place immediately. When the light intensity calibration is complete, the message *Ready to monitor* appears in the *Cal messages* window.

   NOTE: A light intensity calibration occurs automatically when a venous blood gas calibration is performed. See the following page for the venous blood gas calibration procedure.

   Once the light intensity calibration has been performed, all light intensity signals are compared to the stored signal. If the detected light intensity signal becomes significantly different from the stored value, an alarm will occur and one of the following messages will be displayed in the SvO2 parameter window: *Damped intensity, High intensity, Low intensity*.

   NOTE: There will be no light intensity alarms until a light intensity calibration is performed.

Calibrate to Venous Blood Gas

Calibrate to venous blood gas for the following conditions:

- Catheter has been placed in a patient without performing the preinsertion calibration procedure.
- Catheter has been disconnected from the optical module for an extended period of time and then reconnected.
- Catheter has been in place for an extended period of time.
- Fiberoptics have been damaged.
- There is reason to suspect that the SvO2 value is incorrect.

If a venous blood gas calibration is performed, it should be done when the patient's oxygen saturation is relatively stable and the light intensity signal is within normal limits (three asterisks displayed in the SvO2 parameter window).

NOTE: To achieve the accuracy ascribed to the SvO2 module, calibration to a mixed venous blood gas should be done using measured oxyhemoglobin saturation values—not calculated values. Oxyhemoglobin saturation values that have been calculated on the basis of measurements of PO2, pH, and temperature have been shown to be inaccurate.

Follow this procedure:

1. Select the *Cal to venous blood gas* option from the SvO2 control window. A new set of menu options is displayed.

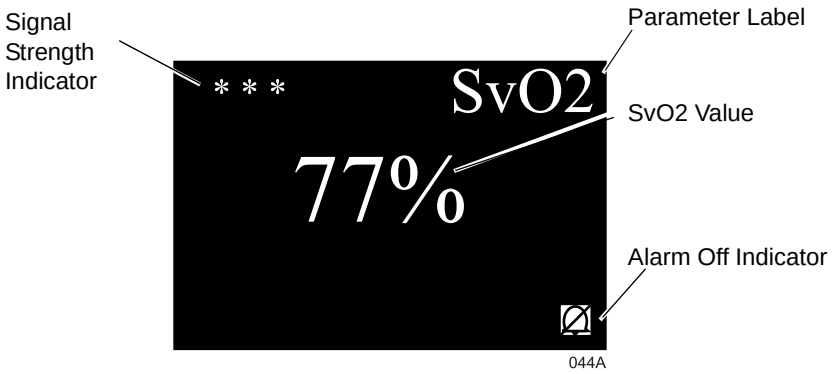
   The message *Draw blood now* is displayed in the *Cal messages* window for 10 seconds. Then the message *Waiting for blood gas* will be displayed. Also, at this time, the SvO2 module will store the preceding 5 seconds of oxygen saturation data and automatically perform the light intensity calibration.

2. If you wish to cancel the blood gas calibration, select *Cancel*. This will cancel the calibration procedure and monitoring will continue using the previously stored saturation value.

3. Once the laboratory analysis is complete, the results can be compared to the stored saturation value, as displayed in the *Store value* window. If the laboratory value is within four saturation units of the stored value, select *Store value*. If the laboratory value differs from the stored value by more than four saturation units, select the *Change value* option and enter the laboratory value. Then select the *Store value* option. The message *Blood gas calibration complete* will appear in the *Cal messages* window.

SvO2 Parameter Window

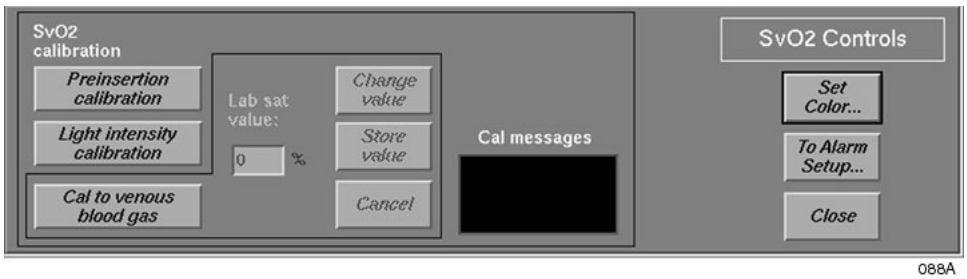
The SvO2 parameter window displays the SvO2 value and signal strength. For more information on signal strength, refer to “Signal and Data Validity” earlier in this chapter.



SvO2 Parameter Window

SvO2 Controls Window

To access the *SvO2 Controls* window, select the *Respiratory* lower control button and choose *SvO2* from the popup menu. The *SvO2 Controls* window can also be opened by touching or clicking on the SvO2 parameter window.



***SvO2 Controls* Window**

SvO2 Calibration

The *SvO2 calibration* control contains three buttons: *Light intensity calibration*, *Preinsertion calibration*, and *Cal to venous blood gas*. For more information on these calibration functions, refer to "SvO2 Calibration" in this chapter.

Cal Messages

The *Cal messages* window displays only the current SvO2 calibration messages.

SvO2 Controls

The *SvO2 Controls* also offer buttons which open/activate other related areas/functions. These buttons are:

Set Color…

To Alarm Setup…

Close

Troubleshooting

Problem: Preinsertion Cal Failure message is displayed.

Solution:

Preinsertion calibration was unsuccessful.

1. Check connections between the optical module and the SvO2 module.
2. Check connections between the optical module and the catheter.
3. Verify the tip of the catheter is in the optical reference block.
4. Check optical module.*
5. Replace catheter.

*See below for optical module test procedure.

Problem: Low Light, Check Probe or No Light, Check Probe message is displayed.

Solutions:

Catheter is out of package but not in the patient. Message is normal.

Catheter is in package.

1. Check connections between the optical module and the SvO2 module.
2. Check connections between the optical module and the catheter.
3. Verify the tip of the catheter is in the optical reference block.
4. Check optical module.*

*See below for optical module test procedure.

Catheter is in patient.

1. Check connections between the optical module and the SvO2 module.
2. Check connections between the optical module and the catheter.
3. Manipulate the catheter to see if the message will clear.
4. Check optical module.*

*See below for optical module test procedure.

Optical Module Test Procedure

If *Low Light, Check Probe* or No *Light, Check Probe* message fails to clear after attempting the solutions above, follow this procedure to check the optical module.

1. Disconnect catheter from optical module.
2. Close the optical module's lid and remove from direct light.
   a. If status message clears, the catheter is damaged and should be replaced.
   b. If the status message does not clear, the optical module or SvO2 module is faulty. Contact Service.

Problem: "--" displayed in SvO2 parameter window.

Solutions:

- Optical module has just been connected and catheter is in the package with the tip in optical reference. Perform preinsertion and light intensity calibrations.
- Optical module has just been connected and catheter is in the patient. Perform venous blood gas calibration.
- Neither of the above conditions apply or none of the solutions work. Contact service.

Problem: Hardware Fault message is displayed.

Solution:

Contact service.

For your notes

17 CO2 Monitoring

For your notes

Introduction

End-tidal CO2 monitoring (referred to as CO2 monitoring in this manual) is a continuous, noninvasive technique for determining the concentration of CO2 (carbon dioxide) in respiratory gas by measuring the absorption of infrared light of specific wavelengths.

The light generated in the analyzer bench is passed through respiratory gas samples. The amount of absorption by CO2 in the sample is measured and digitized by the photodetector. The module processes the electronic signal and displays on the monitor a waveform (labeled CO2) and digital values for expired CO2 (E), inspired CO2 (I), and respiratory rate (Resp).

Depending on the module used, the monitor can accommodate both intubated and non-intubated patients.

CO2 monitoring is done with one of GE Medical Systems *Information Technologies* CO2 modules:

Capnostat Mainstream CO2 module—for intubated patients

Capnostat Dual CO2 module—refer to Note below

NOTE: When using the Capnostat Dual module, we recommend using the mainstream method for intubated patients, and the sidestream method for non-intubated patients.

Sidestream CO2 module—for either intubated or non-intubated patients

CO2 monitoring is also done with GE Medical Systems *Information Technologies* Smart Anesthesia Multi-Gas (SAM) Module and the Random Access Mass Spectrometer (RAMS) unit.

Setup, safety, and gas monitoring information specific to the SAM module and the RAMS unit is addressed in Chapter 18, Anesthesia Gas Monitoring.

All information on CO2 monitoring, regardless of the data acquisition source, is covered in this chapter.

CO2 Monitoring Features

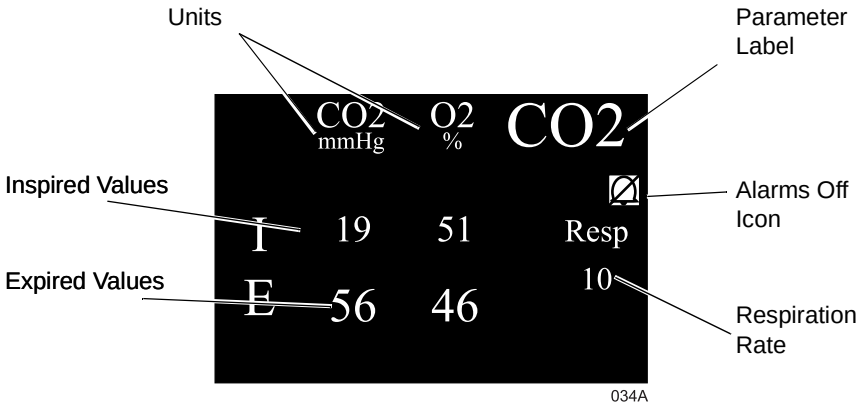
CAUTION
Do not attempt to use a combination of gas monitoring modules/systems (e.g., CO2, SAM, or RAMS) at the same time. Only data from the first acquisition source to detect CO2 or gases will be displayed.

When initiating CO2 monitoring (placing a module in the Tram-rac housing and connecting the patient sampling line), there is a warming up period (less than four minutes). The message *Warming Up* is displayed in the CO2 parameter window.

After the warm-up period, when the patient is properly connected and breath is detected, numerics are displayed in the CO2 parameter window and a CO2 waveform may be displayed on the screen.

Capnostat modules—When using one of the Capnostat modules, after the initial warming up period, when a new Capnostat sensor is connected, the message *Calibrate CO2 Sensor To Zero Cell* is displayed. You must zero the Capnostat sensor before monitoring can start. This is normal, as anytime a new Capnostat sensor is used, it must be zeroed. (Refer to this chapter, Zero Capnostat Sensor.)

CO2 Parameter Window



CO2 Parameter Window

The parameter window displays the values for inspired and expired CO2 and a respiration rate.

The CO2 monitoring features are found in the *CO2 Controls* window. The features available depend on the CO2 module you use. Basic features of all modules include units of measure, scales, and limits.

Capnostat Modules

General Information

CAUTIONS

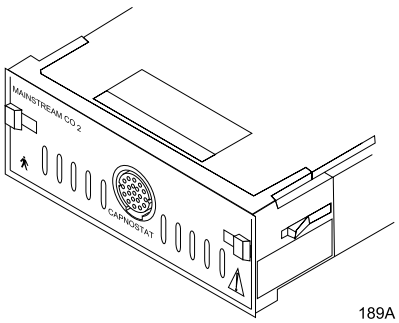
The Capnostat CO2 sensor should not be used in close proximity to wireless networking equipment or in the presence of strong electromagnetic fields such as those generated by radio station transmitters, citizens band radios, cellular phones, etc. Using the Capnostat sensor under the above conditions may cause one or all of the following to occur:

- Artifact may be induced on the capnogram.
- The CO2 parameter values may be replaced by X.
- The message "*CHECK ADAPTER*" may be displayed in the parameter window.

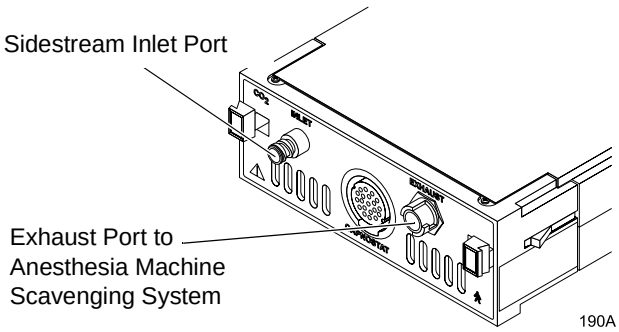
Normal operation will resume when the source of interference is removed.

WIRELESS LAN INTERFERENCE—Capnostat sensors with a serial number 26104 or greater require a separation distance of 10 inches (0.25 meters) from the wireless LAN adapter to minimize potential interference. Capnostat sensors with a serial number earlier than 26104 require a separation distance of 8.2 feet (2.5 meters) and are not recommended for use on monitoring equipment equipped with the wireless LAN option.

There are two Capnostat CO2 modules, one which is strictly a mainstream module, and one which is either a mainstream or a sidestream module (dual mode module).

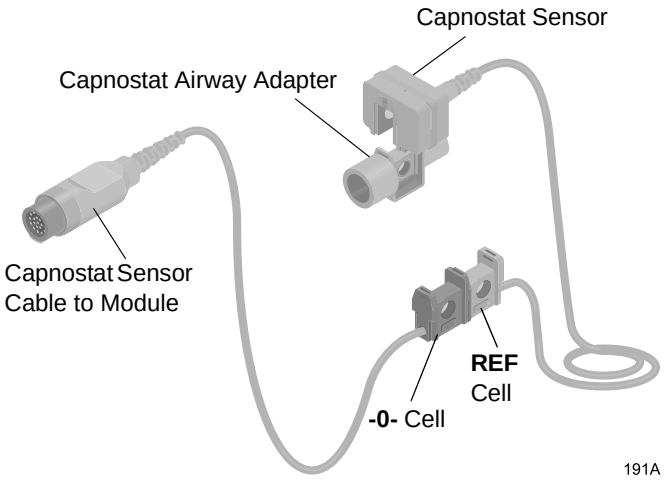


Capnostat Mainstream CO2 Module



Capnostat Dual CO2 Module

The Capnostat modules must be used with a Capnostat sensor and airway adapter. There is a Capnostat airway adapter for mainstream monitoring (pictured below) and also a Capnostat sidestream adapter with sample tubing for sidestream monitoring (not shown). The sensor cable is equipped with two cells. The **-0-** cell is used for zeroing (calibration) of the sensor and the **REF** cell is used for verifying sensor accuracy.



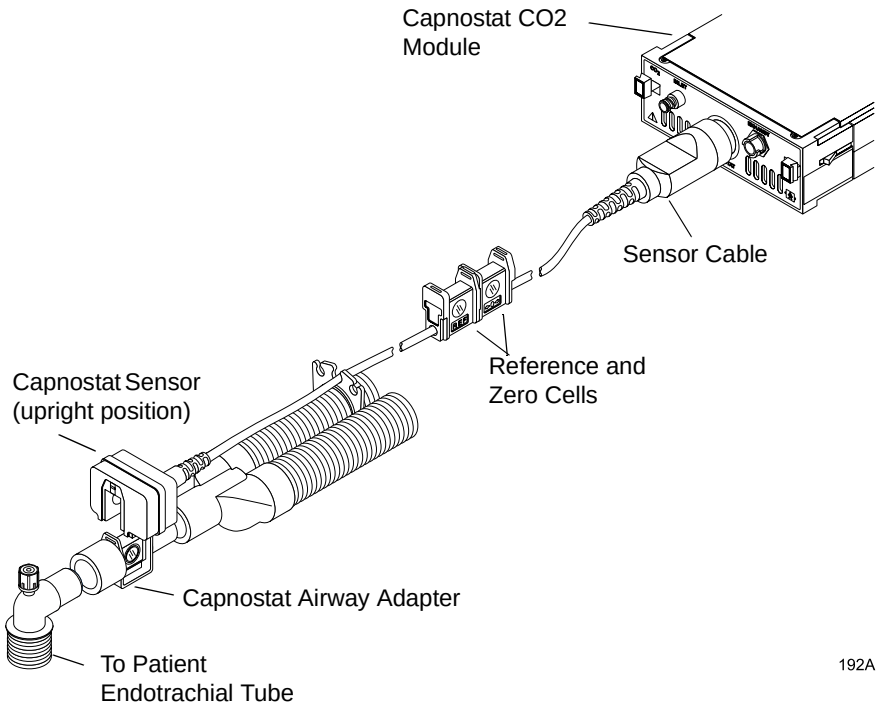
Capnostat Sensor, Cable, and Airway Adapter

Mainstream Setup

The mainstream setup for both Capnostat modules is identical.

1. Securely insert the module into the Tram-rac housing.
2. Connect the Capnostat sensor cable to the module. If the message *Calibrate CO2 Sensor to Zero Cell* is displayed in the CO2 parameter window, you need to zero the sensor. (Refer to this chapter, Zero Capnostat Sensor.)
3. Confirm that the monitor's barometric pressure setting is correct. (Refer to this chapter, Zero Capnostat Sensor.)
4. Snap the Capnostat airway adapter into the Capnostat sensor. If the message *Check Adapter Calibration* is displayed in the CO2 parameter window, you need to calibrate the adapter. (Refer to this chapter, CO2 Calibration.)
5. Position adapter and sensor in patient respiratory circuit as close to the patient as possible between the endotracheal tube and the ventilator circuit.

NOTE: Always position the sensor with adapter in an upright position to avoid collection of fluids on the windows of the adapter. Large concentrations of fluids at this point will obstruct gas analysis.



Mainstream Setup

Sidestream Setup (Dual Module)

CAUTION
The Capnostat dual CO2 module's sidestream withdrawal rate is 180 milliliters per minute (nominal). Do not use this module on any patient who may be affected by this withdrawal rate.

1. Securely insert the module into the Tram-rac housing.
2. Connect the Capnostat sensor cable to the module. If the message *Calibrate CO2 Sensor To Zero Cell* is displayed in the CO2 parameter window, you need to zero the sensor.
3. Confirm that the monitor's barometric pressure setting is correct. (Refer to this chapter, Zero Capnostat Sensor.)
4. Connect the sidestream adapter tubing to the inlet connector on the module.
5. When delivering anesthetics, connect scavenging tube to the **EXHAUST** connector on the module. (Refer to Gas Exhaust in this chapter.)
6. Attach the 5-inch adapter tubing (male-to-male) connector to the airway adapter.
7. Secure the Aqua-Knot water trap to the 5-inch adapter tubing.

   NOTE: The Aqua-Knot water trap must be used. The arrow on the water trap shows the direction of the gas flow. When inserting the water trap, the arrow should point toward the module.

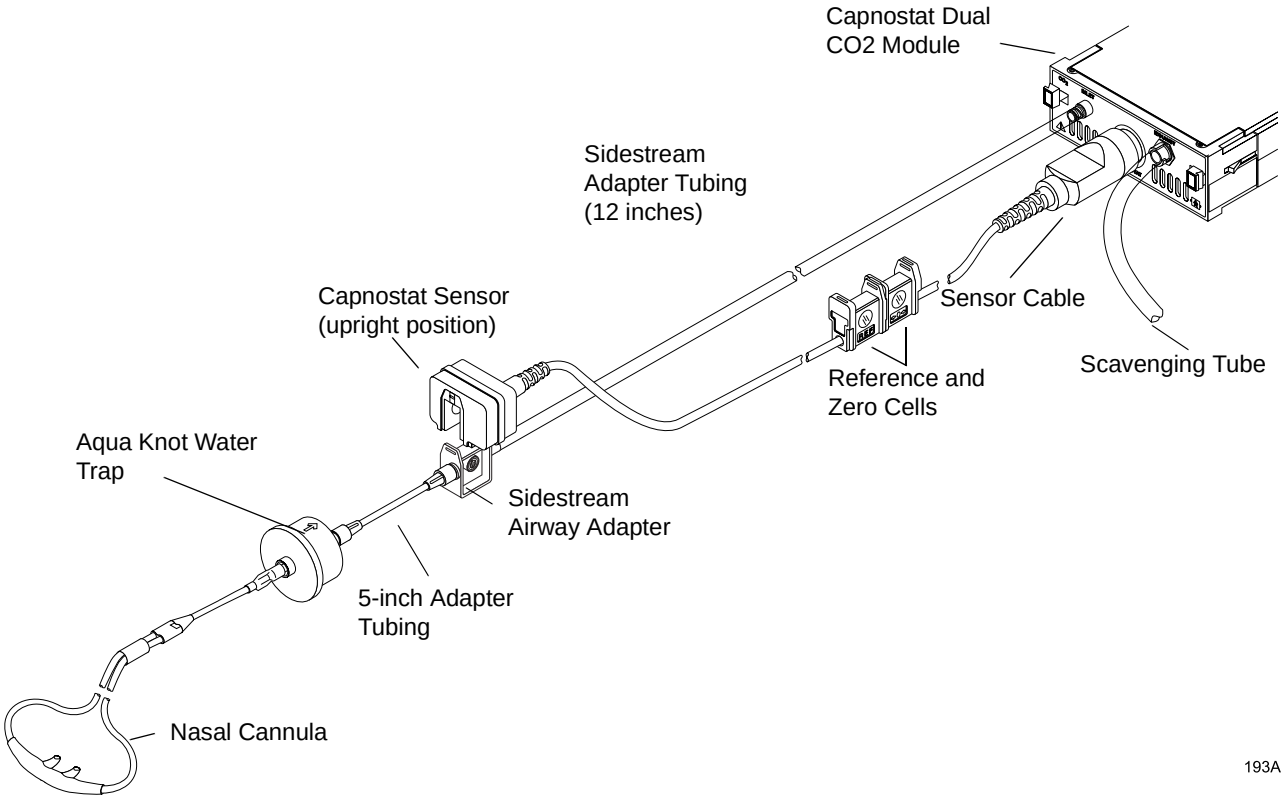
8. Connect the nasal cannula to the Aqua-Knot water trap.
9. Turn the pump on by selecting *On* from the *Pump* option in the *CO2 Controls* window.
10. Snap the Capnostat sidestream adapter with its tubing into the Capnostat sensor. If the message *Check Adapter Calibration* is displayed in the CO2 parameter window, you need to calibrate the adapter. (Refer to this chapter, Calibrate Capnostat Adapter.)
11. Occlude the open end of the airway circuit. *A BLOCKED LINE* message appearing in the CO2 parameter window verifies a clear breathing circuit.

CAUTION
The sidestream analyzer will not detect a leak in the breathing circuit. A leak in the breathing circuit may cause inaccurate readings.

12. Position the nasal cannula on the patient according to the manufacturer's instructions.

Refer to the figure on the next page for an illustration of a sidestream setup.

Non-Intubated Patient Setup



Sidestream Setup for Non-Intubated Patient

Gas Exhaust

When using the sidestream method for monitoring CO2 and anesthetic agents are being delivered, the exhaust gas must be considered. The exhaust gas may be scavenged using the scavenging adapter package (PN 9504-016). Follow the steps listed below to properly connect the module to an anesthesia machine exhaust circuit.

CAUTIONS

EXHAUST LINE—Do not allow the exhaust line to become kinked or blocked. Back pressure may cause inaccurate gas readings and also may cause serious damage to the module's internal components.

INFECTIOUS DISEASE—To avoid the spread of infectious disease, do not allow the exhaust to discharge in the direction of the patient or user.

VACUUM SOURCE—Do NOT connect exhaust of the module to an unregulated, high vacuum source. Vacuum may cause inaccurate gas readings and also may cause serious damage to the equipment's internal components.

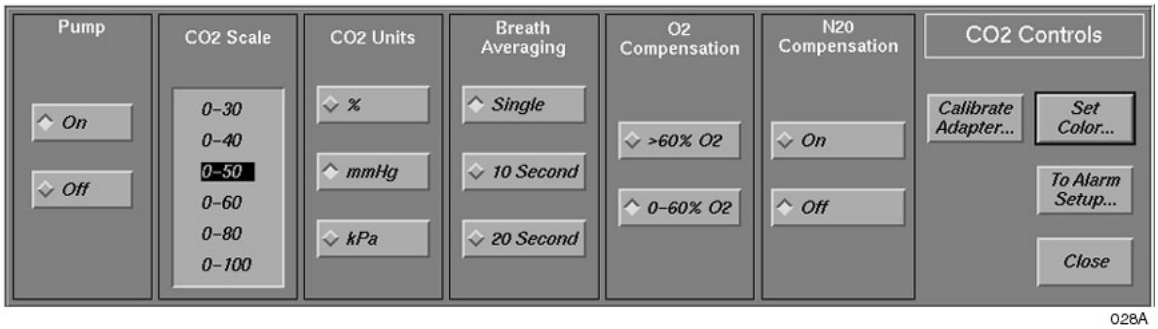
NOTE: Replace and dispose of the Aqua-Knot water trap when occluded. Do not reuse. Reusing the water trap may cause inaccurate readings and may damage the equipment.

1. Remove exhaust adapter and tube from the package.
2. Attach connector end of exhaust tube to outlet marked **EXHAUST** on the front of the module.
3. Install exhaust adapter into gas scavenging system of anesthesia delivery system following anesthesia machine manufacturer's recommended procedure.
4. Drape exhaust tube so that it does not obstruct work area.

CO2 Monitoring

CO2 Controls Window

To access the *CO2 Controls* window, touch or click on the CO2 parameter window, or select *CO2...* from the *Respiratory* lower control popup menu.



***CO2 Controls* Window — Capnostat modules**

You now can select any of the displayed options.

Pump

NOTE: The *Pump* option is only available when using the Capnostat dual module.

Use the *Pump* option to turn the module's pump on and off. The pump must be on when using the sidestream method of monitoring CO2. The pump will turn on at power up, and turn off in five minutes if no CO2 is detected.

CO2 Scale

The *CO2 Scale* option allows you to choose an appropriate scale for the best resolution of the displayed CO2 waveform. The scale choices will be different depending on the units of measure being used. A waveform that exceeds the allowed display area on the screen will be flattened on top. Adjust the scale to reduce the waveform size. Selecting a large scale value reduces the size of the waveform. Conversely, a smaller scale value increases the size of the waveform.

The *CO2 Scale* default is *0–50* mmHg.

CO2 Units

The *CO2 Units* option allows you to choose the unit of measure for inspired and expired CO2—*mmHg*, *%*, or *kPa* (kilopascals). The units selected here are reflected in the CO2 parameter block and waveform reference label. This unit will be reflected throughout limits, trends, and printing.

The default for *CO2 Units* is *mmHg*.

NOTE: Respiration is always measured in breaths per minute, and No Breath is always measured in seconds.

Breath Averaging

The *Breath Averaging* controls allow you to select a time interval for averaging CO2:

Single—CO2 value is calculated for every breath.

10 Second—CO2 value is calculated using 10 seconds of data.

20 Second—CO2 value is calculated using 20 seconds of data.

The default for *Breath Averaging* is *Single*.

O2 Compensation

The presence of a large concentration of oxygen causes the displayed CO2 value to be lower than the actual value. Use this option to compensate for the presence of O2.

This is a direct action menu option which switches between *0-60% O2* and *>60% O2*. Your selection depends on the amount of O2 present.

NOTE: O2 concentration can be obtained from an oxygen analyzer.

The default for *O2 Compensation* is *0–60% O2*.

N2O Compensation

Selecting *N2O Compensation* allows you to compensate for interaction of N2O on CO2 readings. The options are *On* and *Off*.

The presence of nitrous oxide causes the displayed CO2 value to be higher than the actual value. Use this option to compensate for the presence of N2O.

The correction is applied to the displayed values of end-tidal CO2. The waveform is also adjusted.

NOTE: N2O concentration can be obtained from the anesthesia machine.

The default for *N2O Compensation* is *Off*.

CO2 Controls

The *CO2 Controls* window also offers buttons which open/activate other related areas/functions. These buttons are:

Calibrate Sensor.../Calibrate Adapter... (The label text on this button varies, depending on whether it is the sensor or the adapter that needs calibrating.)

- For more information on calibrating the sensor, refer to Zero Capnostat Sensor in this chapter.
- For more information on calibrating the adapter, refer to CO2 Calibration in this chapter.

Set Color…

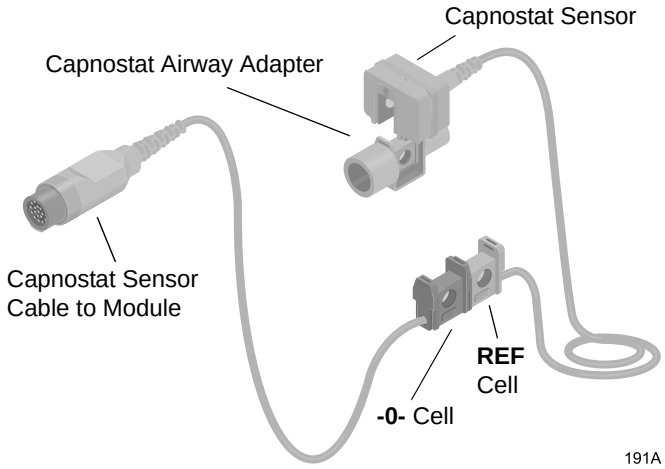
To Alarm Setup…

Close

Zero Capnostat Sensor

The message *Calibrate CO2 Sensor to Zero Cell* indicates the need to zero the sensor.

The sensor cable has two cells as shown in the figure below. One is marked "**-0-**" (zero), and one is marked "**REF**" (reference).

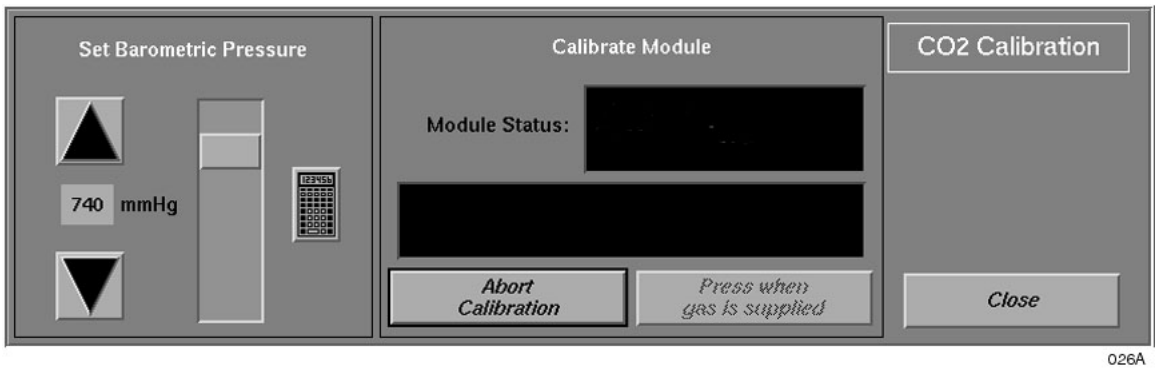


Capnostat Sensor, Cable, and Airway Adapter

Zeroing the Sensor

To zero the sensor follow this procedure:

1. Remove the adapter from the sensor but be certain the sensor cable is still connected to the module.
2. Place the sensor on the cell marked "**-0-**." (See the figure above.)
3. Open the *CO2 Controls* window by touching or clicking on the CO2 parameter window or by selecting *CO2* from the *Respiratory* popup menu.
4. Select the *Calibrate Sensor* option. The *CO2 Calibration* window opens.



***CO2 Calibration* Window**

5. Set the barometric pressure based on the average barometric pressure for your locale.
6. Select *Start Calibration*. The message *Calibrating* is displayed in the CO2 parameter window. When calibration is complete, the *CO2 Calibration* window closes and the message clears.
7. Remove the sensor from the "**-0-**" cell and place it on the "**REF**" cell. An expired value of 38 mmHg (±2 mmHg) is displayed. If the value is not within this range, the sensor is out of tolerance and should be replaced.

Calibrate Capnostat Adapter

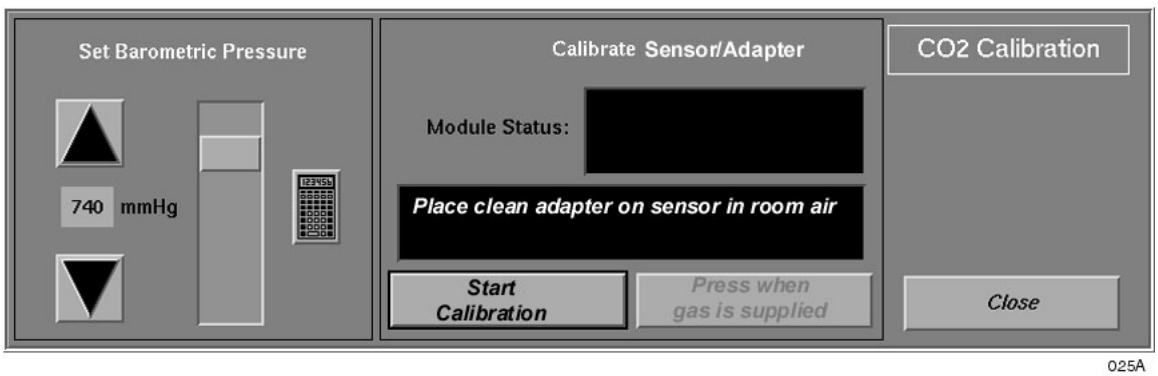
The message *Calibrate CO2 Adapter* indicates the need to calibrate the adapter. Before calibrating, make sure the airway adapter is clean and clear of foreign matter. An adapter calibration is required under the following conditions:

- Whenever you change adapter types, for example, adult to low dead space, or mainstream to sidestream.
- When the monitor requests it (*Check Adapter Calibration* message).

Follow this procedure to calibrate the adapter:

1. Place the sensor and adapter away from all sources of CO2, including the patient's and your own exhaled breath and ventilator exhaust valves.
2. Set the barometric pressure based on the average barometric pressure for your locale.
3. With the adapter connected to the sensor and the sensor connected to the monitor, select the *Calibrate Adapter* option from the *CO2 Controls* window. The *CO2 Calibration* window opens.

NOTE: Prior to calibrating the Capnostat sidestream adapter, all sampling tubing must be attached and the pump turned on.



***CO2 Calibration* Window**

4. The prompt *Place clean adapter on sensor in room air* is displayed. Select *Start Calibration*. The message *Calibrating* is displayed in the CO2 parameter window. When calibration is complete, the *CO2 Calibration* window closes and the message clears.

Capnostat Sensor and Adapter Cleaning

Cleaning the Capnostat Sensor

- Clean the sensor surface with a damp cloth.
- Ensure the sensor windows are clean and dry.
- Do NOT immerse the sensor.
- Do NOT attempt to sterilize the sensor.

Cleaning the Reusable Capnostat Adapters

- An adapter can be cleaned by rinsing in a warm soapy solution, followed by soaking in a liquid disinfectant, or it can be pasteurized or cold sterilized (glutaraldehyde). It should then be rinsed with sterile water and dried.

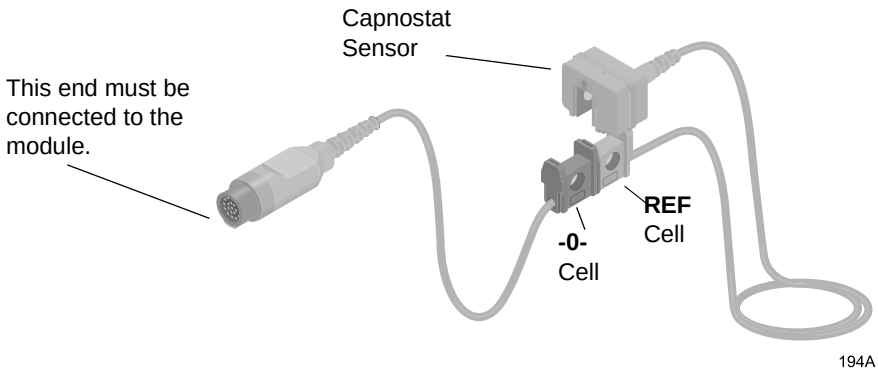
NOTE: The sidestream adapter should only be cold cleaned. The interior of the tubing can be dried by flushing with air or oxygen.

- The adult and low volume dead space adapters may be sterilized using the ETO (ethylene oxide) gas method. They may also be sterilized using a steam autoclave method but lifetime could be affected.
- Before reusing any adapter, ensure that the windows are dry and residue-free, and that the adapter has NOT been damaged during handling or by the cleaning/sterilization process.

Capnostat Sensor Troubleshooting

Capnostat Sensor Check

The sensor cable has two cells as shown in the figure below. One is marked "**-0-**" (zero), and one is marked "**REF**" (reference). Whenever you suspect incorrect values or sensor failure, perform a sensor check.



Sensor Check and Calibration Cells

Sensor Check:

1. Remove the adapter from the sensor but be certain the sensor cable is still connected to the module.
2. Place the sensor on the cell marked "**REF**." Depending on the units of measure, you should see a reading of 38 mmHg (±2) on the display. If the displayed value is within range, you can resume monitoring. If the sensor is not within range, an error message "*NOT CALIBRATED*" will be displayed. You must calibrate the sensor to the zero cell (refer to Zero Capnostat Sensor in this chapter).

WARNING

The end-tidal CO2 value (etCO2) is in most cases considerably lower than the CO2 partial pressure determined by blood-gas analysis. The major clinical reasons are:

- dead-space ventilation, ventilation/perfusion mismatch
- drop in cardiac output
- alveolar shunts
- incomplete emptying of the alveoli

TECHNICAL REASONS (MUST BE CORRECTED):

- leak in the respiration tube system
- hypothermia, but blood-gas analysis at 37°C
- anesthesia gases (correction possible for O2 and N_2O only)

Sidestream CO2 Module

CAUTIONS

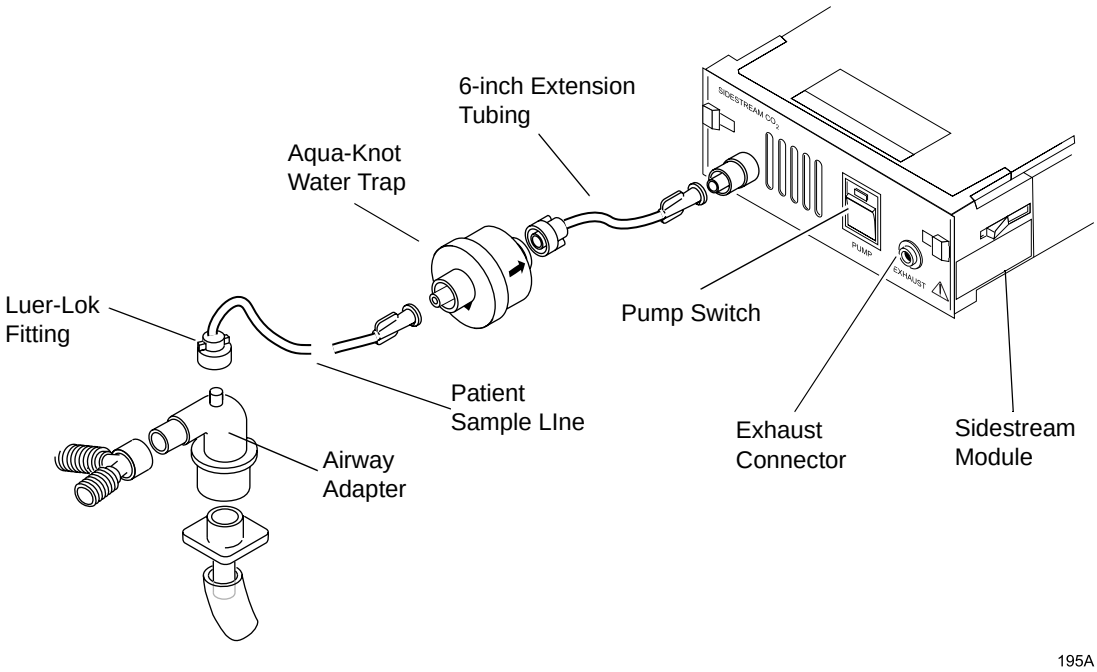
PREVENT CONTAMINATION—Be sure the pump is off before removing the Aqua-Knot water trap to prevent contamination of the internal gas measurement instruments.

WATER TRAP—An Aqua-Knot water trap must always be used when the unit is running. Failure to use the water trap can result in contamination of the internal gas measurement instruments and may cause subsequent inaccurate gas analysis data.

Replace and dispose of the Aqua-Knot water trap when occluded. Do not reuse. Reusing the water trap may cause inaccurate readings and may damage the equipment.

WITHDRAWAL RATE—The GE Medical Systems *Information Technologies* Sidestream CO2 Module continuously withdraws 200 milliliters per minute from the patient airway. Do not use this module on any patient who may be affected by this withdrawal rate.

Sidestream Module Setup



Sidestream Module Setup

The airway adapter is placed between the endotracheal tube and the breathing circuit to the ventilator or humidified oxygen source. A pump in the module draws the gas from a Luer-lok fitting located on the airway adapter, through a sampling line, through our Aqua-Knot water trap, through the 6-inch extension tubing, and into the module. Analysis takes place inside the module.

NOTE: For non-intubated patients, the sidestream module can be used with a CO2 sampling nasal cannula.

NOTE: Always position the Luer-Lok connection and patient sample line in an upright position to avoid aspiration of fluids into the patient sample line which will cause premature blockage.

Delivery of bronchodilators, mucolytics via aerosol, and meter dose inhalers will cause premature blockage of the Aqua-Knot water trap. Discontinue gas analysis prior to treatment by switching the pump off and removing the airway adapter from the ventilator circuit, or disconnecting the sample line from the Aqua-Knot water trap.

Pump Control

To turn the pump on and off (standby mode), press and release the pump switch located on the front of the module. The green light just above the switch is illuminated whenever the pump is on.

Gas Exhaust

The gas exhaust may be scavenged using the scavenging adapter package (PN 9504-016) included with each Sidestream CO2 module. Follow the steps listed below to properly connect the Sidestream module to an anesthesia machine exhaust circuit.

CAUTIONS

EXHAUST LINE—Do not allow the exhaust line to become kinked or blocked. Back pressure may cause inaccurate gas readings and also may cause serious damage to the module's internal components.

INFECTIOUS DISEASE—To avoid the spread of infectious disease, do not allow the exhaust to discharge in the direction of the patient or user.

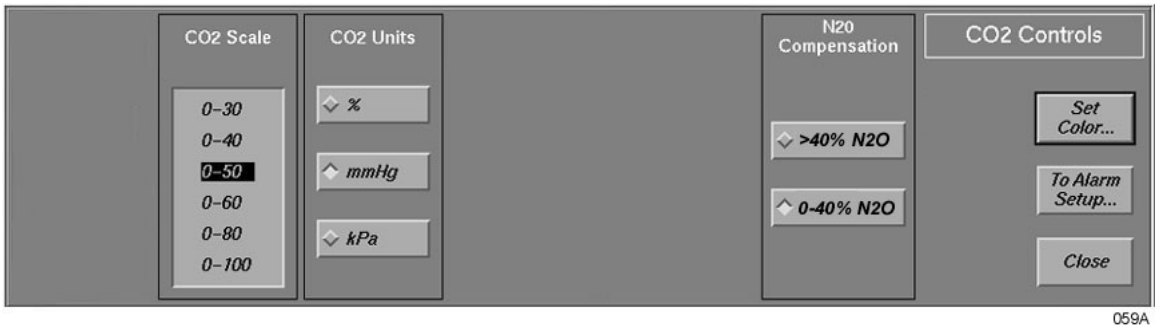
VACUUM SOURCE—Do NOT connect exhaust of the module to an unregulated, high vacuum source. Vacuum may cause inaccurate gas readings and also may cause serious damage to the equipment's internal components.

1. Remove exhaust adapter and line from the package.
2. Attach connector end of exhaust line to outlet marked **EXHAUST** on the front of the module.
3. Install exhaust adapter into gas scavenging system of anesthesia delivery system following anesthesia machine manufacturer's recommended procedure.
4. Drape exhaust line so that it does not obstruct work area.

CO2 Monitoring

CO2 Controls Window

To access the *CO2 Controls* window, touch or click on the CO2 parameter window, or select *CO2...* from the *Respiratory* lower control popup menu.



***CO2 Controls* Window — Sidestream CO2 module**

You now can select any of the displayed options.

CO2 Scale

The *CO2 Scale* option allows you to choose an appropriate scale for the displayed CO2 waveform. The scale choices will be different depending on the units of measure being used. A waveform that exceeds the allowed display area on the screen will be flattened on top. Adjust the scale to reduce the waveform size. Selecting a large scale value reduces the size of the waveform. Conversely, a smaller scale value increases the size of the waveform.

The *CO2 Scale* default value is *0–50* mmHg.

CO2 Units

The *CO2 Units* option allows you to choose the unit of measure for inspired and expired CO2—*mmHg*, *%*, or *kPa* (kilopascals). The units selected here are reflected in the CO2 parameter block and waveform reference label. This unit will be reflected throughout limits, trends, and printing.

The default for *CO2 Units* is *mmHg.*

NOTE: Respiration is always measured in breaths per minute, and *No Breath* is always measured in seconds.

N2O Compensation

Selecting *N2O Compensation* allows you to compensate for interaction of N2O on CO2 readings. The options are *0-40% N2O* and *>40% N2O*. Your selection depends on the amount of N2O present.

The presence of nitrous oxide causes the displayed CO2 value to be higher than the actual value. Use this option to compensate for the presence of N2O.

The correction is applied to the displayed values of end-tidal CO2. The waveform is also adjusted.

NOTE: N2O concentration can be obtained from the anesthesia machine.

The default for N2O compensation is *0–40% N2O*.

CO2 Controls

The *CO2 Controls* window also offers buttons which open/activate other related areas/functions. These buttons are:

Set Color…

To Alarm Setup…

Close

SAM Module

Setup, safety, and gas monitoring information specific to the SAM module is addressed in Chapter 18, Anesthesia Gas Monitoring.

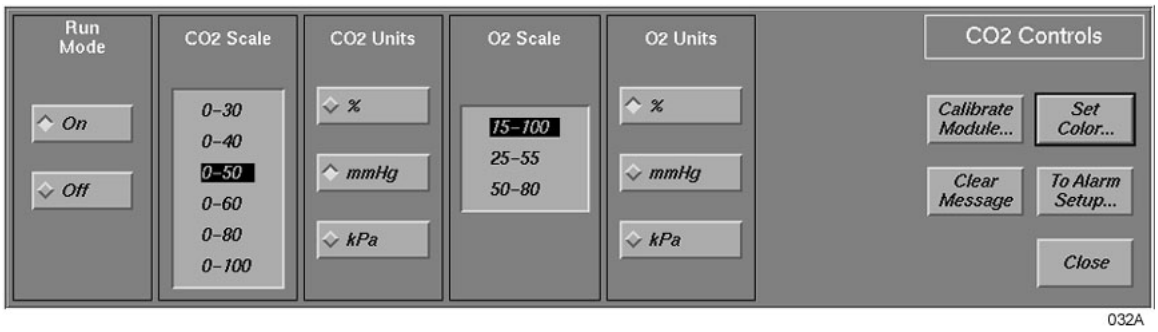
CO2 Monitoring

CO2 Controls Window

To access the *CO2 Controls* window, touch or click on the CO2 parameter window, or select *CO2...* from the *Respiratory* lower control popup menu.

The *CO2 Controls* window that opens will depend upon the SAM module used.

***CO2 Controls* Window — SAM 80 Module**



***CO2 Controls* Window — SAM Module**

You now can select any of the displayed options.

Run Mode

The *Run Mode* control has *On* and *Off* buttons. If the SAM module is present, *On* will be highlighted. You can place the SAM module in standby mode by selecting *Off*. The SAM module will automatically go into standby mode after 5 minutes of no breaths. The SAM module will remain in standby mode until breaths are detected.

CO2 Scale

The *CO2 Scale* option allows you to choose an appropriate scale for the displayed CO2 waveform. The scale choices will be different depending on the units of measure being used. A waveform that exceeds the allowed display area on the screen will be flattened on top. Adjust the scale to reduce the waveform size. Selecting a large scale value reduces the size of the waveform. Conversely, a smaller scale value increases the size of the waveform.

The *CO2 Scale* default value is *0–50* mmHg.

CO2 Units

The *CO2 Units* option allows you to choose the unit of measure for inspired and expired CO2—*mmHg*, *%*, or *kPa* (kilopascals). The units selected here are reflected in the CO2 parameter block and waveform reference label. This unit will be reflected throughout limits, trends, and printing.

The default for *CO2 Units* is *mmHg*.

NOTE: Respiration is always measured in breaths per minute, and *No Breath* is always measured in seconds.

O2 Scale

NOTE: The *O2 Scale* option is NOT available when using the SAM 80 module.

The *O2 Scale* option allows you to choose an appropriate scale for a displayed O2 waveform. The scale choices will be different depending on the units of measure being used.

The *O2 Scale* default value is *15–100*%.

O2 Units

NOTE: The *O2 Units* option is NOT available when using the SAM 80 module.

The *O2 Units* option allows you to choose the unit of measure for inspired and expired O2—*%*, *mmHg*, or *kPa* (kilopascals).

The default for O2 Units is *%*.

O2 Compensation

NOTE: The *O2 Compensation* option is ONLY available when using the SAM 80 module.

The presence of a large concentration of oxygen causes the displayed CO2 value to be lower than the actual value. Use this option to compensate for the presence of O2.

The options are *0-60% O2* and *>60% O2*. Your selection depends on the amount of O2 present.

NOTE: O2 concentration can be obtained from the oxygen analyzer on the anesthesia machine.

The default for *O2 Compensation* is *0-60% O2*.

CO2 Controls

The *CO2 Controls* window also offers buttons which open/activate other related areas/functions. These buttons are:

Calibrate Module...—For more information, refer to CO2 Calibration in this chapter.

Clear Message

Set Color…

To Alarm Setup…

Close

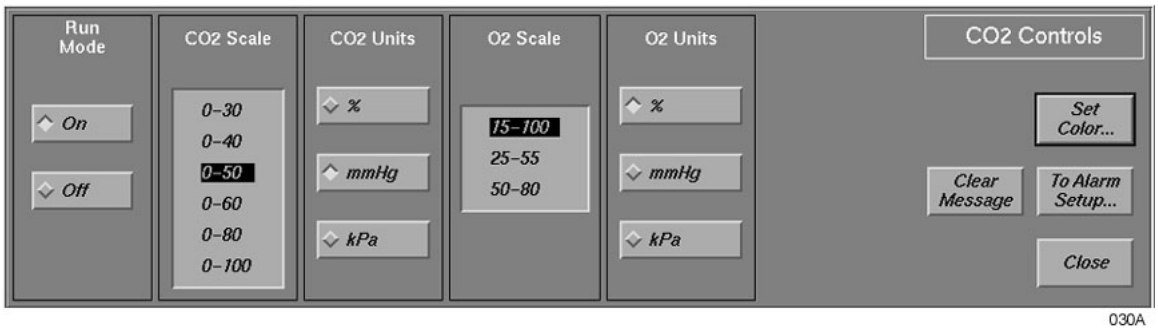
RAMS Unit

Setup, safety, and gas monitoring information specific to the RAMS unit is addressed in Chapter 18, Anesthesia Gas Monitoring.

CO2 Monitoring

CO2 Controls Window

To access the *CO2 Controls* window, touch or click on the CO2 parameter window, or select *CO2* from the *Respiratory* lower control popup menu.



***CO2 Controls* Window — RAMS Unit**

You now can select any of the displayed options.

Run Mode

The *Run Mode* control has *On* and *Off* buttons. If the RAMS unit is present, *On* will be highlighted. You can turn the unit off by selecting *Off*.

If no breaths are detected for a period of one hour, the RAMS unit will automatically enter STANDBY mode. To restart the RAMS unit, select *On* in the *CO2 Controls* window.

CO2 Scale

The *CO2 Scale* option allows you to choose an appropriate scale for the displayed CO2 waveform. The scale choices will be different depending on the units of measure being used. A waveform that exceeds the allowed display area on the screen will be flattened on top. Adjust the scale to reduce the waveform size. Selecting a large scale value reduces the size of the waveform. Conversely, a smaller scale value increases the size of the waveform.

The *CO2 Scale* default value is *0–50* mmHg.

CO2 Units

The *CO2 Units* option allows you to choose the unit of measure for inspired and expired CO2—*mmHg*, *%*, or *kPa* (kilopascals). The units selected here are reflected in the CO2 parameter block and waveform reference label. This unit will be reflected throughout limits, trends, and printing.

The default for *CO2 Units* is *mmHg*.

NOTE: Respiration is always measured in breaths per minute, and *No Breath* is always measured in seconds.

O2 Scale

The *O2 Scale* option allows you to choose an appropriate scale for a displayed O2 waveform. The scale choices will be different depending on the unit of measure being used.

The *O2 Scale* default value is *15–100*%.

O2 Units

The *O2 Units* option allows you to choose the unit of measure for inspired and expired O2—*%*, *mmHg*, or *kPa* (kilopascals).

The default for *O2 Units* is *%*.

CO2 Controls

The *CO2 Controls* window also offers buttons which open/activate other related areas/functions. These buttons are:

Clear Message

Set Color…

To Alarm Setup…

Close

CO2 Calibration

NOTE: The *Calibrate Sensor/Adapter/Module* option is only found in the *CO2 Controls* window when using a Capnostat or SAM module.

Refer to the service manual for information on other CO2 calibrations.

Calibrating the CO2 Adapter

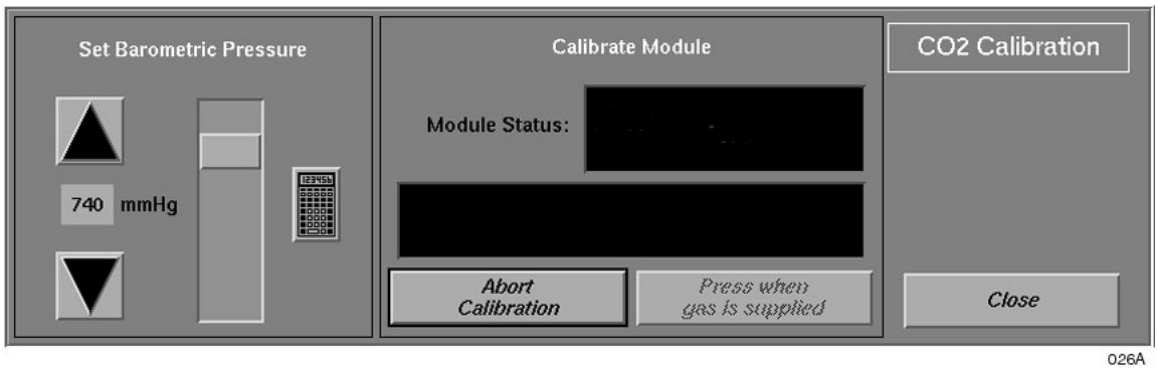
The message *Calibrate CO2 Adapter* indicates the need to calibrate the adapter. Before calibrating, make sure the airway adapter is clean and clear of foreign matter. An adapter calibration is required under the following conditions:

- Whenever you change adapter types, for example, adult to low dead space, or mainstream to sidestream.
- When the monitor requests it (*Check Adapter Calibration* message).

Follow this procedure to calibrate the adapter:

NOTE: Prior to calibrating the Capnostat sidestream adapter, all sampling tubing must be attached and the pump turned on.

1. Place the sensor and adapter away from all sources of CO2, including the patient's and your own exhaled breath and ventilator exhaust valves.
2. With the adapter connected to the sensor and the sensor connected to the monitor (and, when used, all sidestream tubing attached and the pump turned on), select the *Calibrate Adapter* option from the *CO2 Controls* window. The *CO2 Calibration* window opens.



***CO2 Calibration* Window — Capnostat Module**

3. If applicable, check the barometric pressure. If the displayed value needs adjusting, use the slide control or the numeric keypad to ensure the proper value is displayed.
4. When using a Capnostat module, the message *Place clean adapter on sensor in room air* appears.

   Select *Start Calibration*.
5. The message *Calibrating* appears, and the button labeled *Press when gas is supplied* becomes active.
6. Select the *Press when gas is supplied* button to continue the calibration procedure.
7. The message *Calibration complete* appears when Capnostat module calibration is complete.
8. Close the *CO2 Calibration* window.

Calibrating the SAM Module

To calibrate the SAM module, select *Calibrate Module...* in the *CO2 Controls* window. The *CO2 Calibration* window opens.

***CO2 Calibration* Window — SAM Module**

1. Select *Start Calibration* to initiate the calibration procedure.
2. The message *Calibrating* appears, and the button labeled *Press when gas is supplied* becomes active.
3. Select the *Press when gas is supplied* button to continue the calibration procedure.
4. The *CO2 Calibration* window closes automatically when SAM module calibration is complete.

Troubleshooting

Messages

Following is a list of some of the messages that may appear on the monitor when monitoring CO2. Message text appears in bold type, and the acquisition source is listed in parentheses.

The message should clear when normal operating criteria are met or a solution is found. If a message persists, call service.

NOTE: The actual message that appears on your monitor depends on the module being used and the installed software version.

Blocked Line (SAM module, RAMS unit)

Cause: Sample line or exhaust line is blocked.
Solution: Check sample and exhaust lines for blockage.
Replace Aqua-Knot water trap.

Cable Disconnected (Capnostat and Sidestream CO2 modules)

Cause: Sensor cable not connected to module.
Solution: Check sensor cable connection.

Calibrating (SAM module, RAMS unit, and Capnostat modules)

Cause: Acquisition source is out of calibration.
Solution: Calibrate SAM module, call for RAMS service, or zero Capnostat CO2 sensor.

Calibrate RAMS (RAMS unit)

Cause: RAMS calibration interval timer is in alarm, or RAMS is out of calibration.
Solution: Calibrate RAMS.

Calibration Mode (RAMS unit, SAM module)

Cause: User has entered the RAMS unit or SAM module calibration service procedure.
Solution: Exit to continue monitoring.

Calibrate Sensor to Zero Cell (Capnostat modules)

Cause: A new Capnostat sensor was introduced into the system or possible signal drift in sensor electronics.
Solution: Zero the CO2 sensor.

Change Airway Adapter (Capnostat module)

Cause: Sensor signal is out of tolerance.
Solution: Check for obstructions or other defects in the airway adapter. Try another adapter. Call service.

Change Module Cell (SAM module)

Cause: SAM service error.
Solution: Call service.

Check Adapter Calibration (Capnostat modules)

Cause: Capnostat adapter not attached, adapter obstructed, or new adapter was attached.
Solution: Check connections, look for possible obstructions. Calibrate adapter.

Check Sample Line Check Aqua Knot (SAM module, RAMS unit, Capnostat modules)

Cause: Sampling line or exhaust line is blocked.
Solution: Check sample line, Aqua Knot, and exhaust lines for blockage.

CO2 Zero Error (Capnostat modules)

Cause: Capnostat sensor zero failed.
Solution: Replace sensor.

Communication Error (RAMS unit)

Cause: RAMS unit service error.
Solution: Call service.

Connect Aquaknot (RAMS unit and SAM module)

Cause: Aqua-Knot is missing.
Solution: Connect Aqua-Knot.

Connect Cable/Device Off? (RAMS unit)

Cause: RAMS unit power us off, or there is no cable connection.
Solution: Turn the RAMS unit on, or check cable connections.

Gas Liquefied (SAM module)

Cause: Gas cells have liquefied.
Solution: Apply power, wait for module to warm up (30 minutes to 1 hour)

Incompatible Sensor (Capnostat modules)

Cause: Capnostat sensor is of older type and not supported by module software.
Solution: Use only a Capnostat 3 sensor.

Moisture Detected (RAMS unit)

Cause: RAMS unit detects moisture.
Solution: Call service.

No Breath Detected (all acquisition sources)

Cause: No breath detected or sampling line is disconnected from patient airway.
Solution: Check the patient and all patient connections.

Not Calibrated or Not Calibrating (all acquisition sources)

Cause: Sensor signal is out of tolerance.
Solution: Calibrate the sensor on the zero cell, then recheck on reference cell.

Service Mode (all acquisition sources)

Cause: User has entered the service mode.
Solution: Exit to return to monitoring.

Service… messages (all acquisition sources)

Cause: Hardware failure.
Solution: Call service.

Standby (SAM module, RAMS unit)

Cause: Module is waiting to detect CO2 to begin monitoring.
Solution: Monitoring will begin when one breath has been detected or when Run Mode is turned *On*.

Warming Up (all acquisition sources)

Cause: Appears whenever a Capnostat sensor is first plugged in, a Sidestream CO2 or SAM module is placed in a Tram-rac, when a sensor is first powered on, and when the RAMS unit is in warm-up mode.
Solution: Message will clear when warmed up. If it persists beyond 4 minutes, call service.

Unknown Error (Capnostat modules, SAM module)

Cause: Unknown module CO2 error.
Solution: Call service.

18 Anesthesia Gas Monitoring

For your notes

Introduction

In addition to receiving CO2 data from the CO2 modules (addressed in Chapter 17, CO2 Monitoring), the Solar 9500 receives and displays data about anesthetic agents.

NOTE: All information on CO2 monitoring, regardless of the data acquisition source, is covered in Chapter 17, CO2 Monitoring.

GE Medical Systems *Information Technologies* Smart Anesthesia Multi-gas (SAM) module is an infrared based, multi-gas analyzer module that measures inspired and expired values for patient gases and calculates respiratory rate.

GE Medical Systems *Information Technologies* Random Access Mass Spectrometer (RAMS) M-200 is a multi-gas analyzer that measures inspired and expired values for patient gases and calculates respiratory rate.

NOTE: The RAMS unit by itself is not a medical device. Sampling data is not displayed on the RAMS status display window.

SAM Module

Introduction

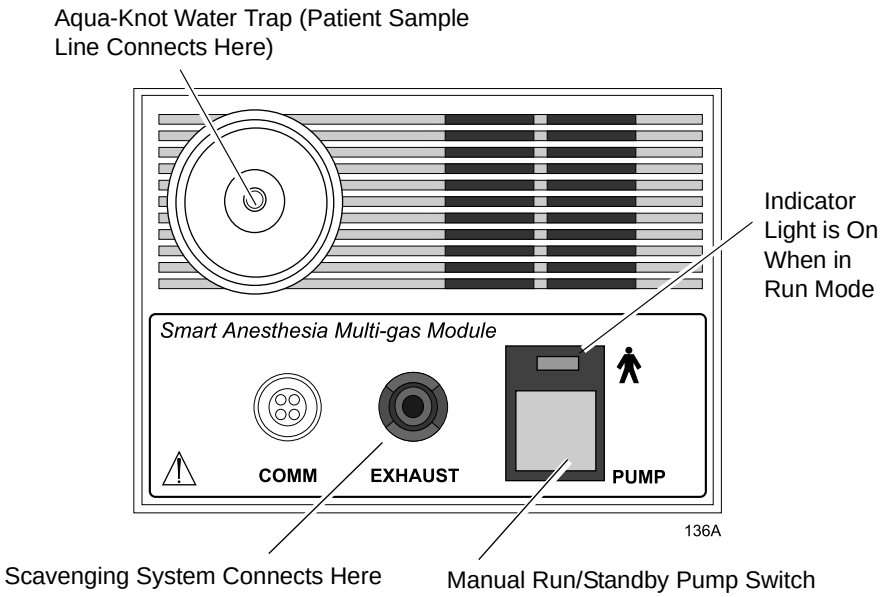
There are two models of the SAM module, one with an O2 sensor and one without. The module without the O2 sensor is labeled in two ways. On the top of the module, there is a label which reads “SAM 80.” In addition, the words “No O2 Sensor” are on the front panel’s label. Operating instructions are identical for both modules. Please ignore any references to O2 if you have the SAM 80 module.

Following is a list of gases the module recognizes and the labels used to identify each on the monitor.

Oxygen (O2)—not available with the SAM 80 module
Carbon dioxide (CO2)
Nitrous oxide (N2O)
Enflurane (ENF)
Halothane (HAL)
Isoflurane (ISO)
Desflurane (DES)
Sevoflurane (SEV)

The Solar 9500 information monitor displays the data measured. The gas information is displayed with all other vital sign information (ECG, pressure, etc.), giving you a better profile of the total patient condition. All patient status alarms are on the monitor, allowing you immediate recognition of a violated parameter. Assessments of the respiratory system in anesthesia can be made with the help of information from the other monitored parameters, and a record can be made.

The SAM module sits in the Tram-rac housing. Sample tubing from the patient connects to the Aqua-Knot water trap on the SAM module.



SAM Module—Front View

Safety Information

Be sure to read all of the following safety information before monitoring a patient with the SAM module.

CAUTIONS

AGENT EXPOSURE—Connect exhaust to a scavenging system to prevent exposure to exhaled agents.

ANESTHETIC AGENT VERIFICATION—When administering anesthetic agents, always verify your anesthetic vaporizer settings.

AQUA-KNOT WATER TRAP—An Aqua-Knot water trap must always be used when the unit is running. Failure to use the water trap can result in contamination of the internal gas measurement instruments and may cause subsequent inaccurate gas analysis data.

Replace and dispose of the Aqua-Knot water trap when occluded. Do not reuse. Reusing the water trap may cause inaccurate readings and may damage the equipment.

ETHANOL AND METHANE—The presence of ethanol or methane with halogenated agents causes inaccuracy in the agent values. Methane, even when no halogenated agent is present, will cause a halothane value to be displayed.

MULTIPLE CO2 MODULES—Do not attempt to use a combination of CO2, SAM, or RAMS modules at the same time. Only data from the first acquisition source to detect CO2 will be displayed.

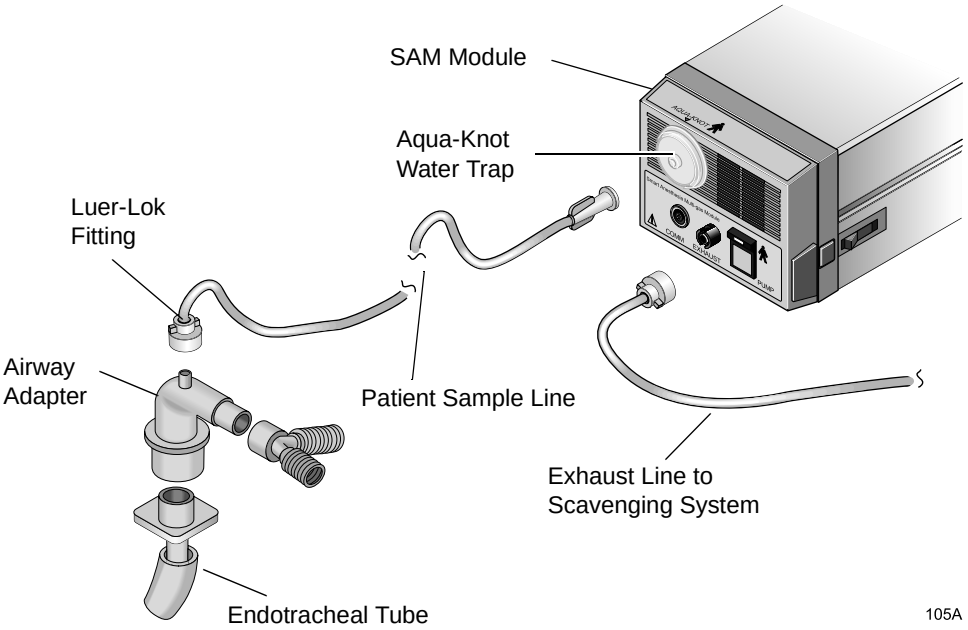
SAMPLE RATE—The SAM module continuously withdraws about 250 milliliters per minute (nominal) from the patient airway. (The SAM 80 module has a withdrawal rate of about 150 milliliters per minute.) Do not use the module on any patient who may be affected by this sampling rate.

NOTE: Always position the Luer-Lok connection and patient sample line in an upright position to avoid aspiration of fluids into the patient sample line which will cause premature blockage of the Aqua-Knot water trap.

Delivery of bronchodilators, mucolytics via aerosol, and meter dose inhalers will cause premature blockage of the Aqua-Knot water trap. Discontinue gas analysis prior to treatment by removing the airway adapter from the ventilator circuit, or by disconnecting the sample line from the Aqua-Knot water trap.

Setup

Connections



SAM Module Setup

NOTE: PE/PVC type patient sample line must be used with the SAM module.

CAUTION
The PE/PVC sample line should have an inner diameter of 0.047 inches. Other size sample line may cause inaccurate data.

1. Insert the Aqua-Knot water trap into the front end of the SAM module; turn clockwise until secure. Do NOT overtighten.

   NOTE: The arrow on the Aqua-Knot water trap shows the direction of the gas flow. When inserting the Aqua-Knot, the arrow should point toward the module.

2. Secure the patient sample line (PE/PVC) to the Aqua-Knot water trap with a Luer-Lok fitting.
3. Connect the airway adapter to the endotracheal tube adapter.
4. Secure the other end of the patient sample line to the airway adapter with a Luer-Lok fitting in an UPWARD position.

   NOTE: For non-intubated patients, a sampling nasal cannula can be used, replacing the patient sample line. The Aqua-Knot water trap must be used.

Gas Exhaust

The gas exhaust may be scavenged using the scavenging adapter package (pn 9504-016) included with each SAM module. Follow the steps listed below to properly connect the module to an anesthesia cart exhaust circuit.

CAUTION
Do NOT connect exhaust of the SAM module to an unregulated high vacuum source. Vacuum may cause inaccurate gas readings and also may cause serious damage to the equipment's internal components.

1. Remove exhaust adapter and line from the package.
2. Attach connector end of exhaust line to outlet marked **EXHAUST** on front of module.
3. Install exhaust adapter into a gas scavenging system.
4. Drape exhaust line so that it does not obstruct work area.

CAUTION
Do NOT allow the exhaust line to become kinked or blocked. Back pressure may cause inaccurate gas readings and also may cause serious damage to the equipment's internal components.

Checklist

1. SAM module is securely inserted in the Tram-rac housing. (You must firmly push the SAM module into the housing and hear the latches click into place.)
2. An Aqua-Knot water trap is inserted in the SAM module.

   NOTE: The arrow on the Aqua-Knot water trap shows the direction of the gas flow. Connect to module with arrow facing the module.

   Do not overtighten the Aqua-Knot water trap. Doing so may damage the Aqua-Knot water trap, causing leaks.
3. Patient sample line is correctly positioned in respiratory circuit and to the Aqua-Knot water trap.
4. Scavenging line is connected to **EXHAUST** connector on SAM module.
5. All components have power on.
6. Make adjustments as necessary using the *CO2 Controls* window and the *GAS Controls* window.

If you suspect a SAM module failure, call service.

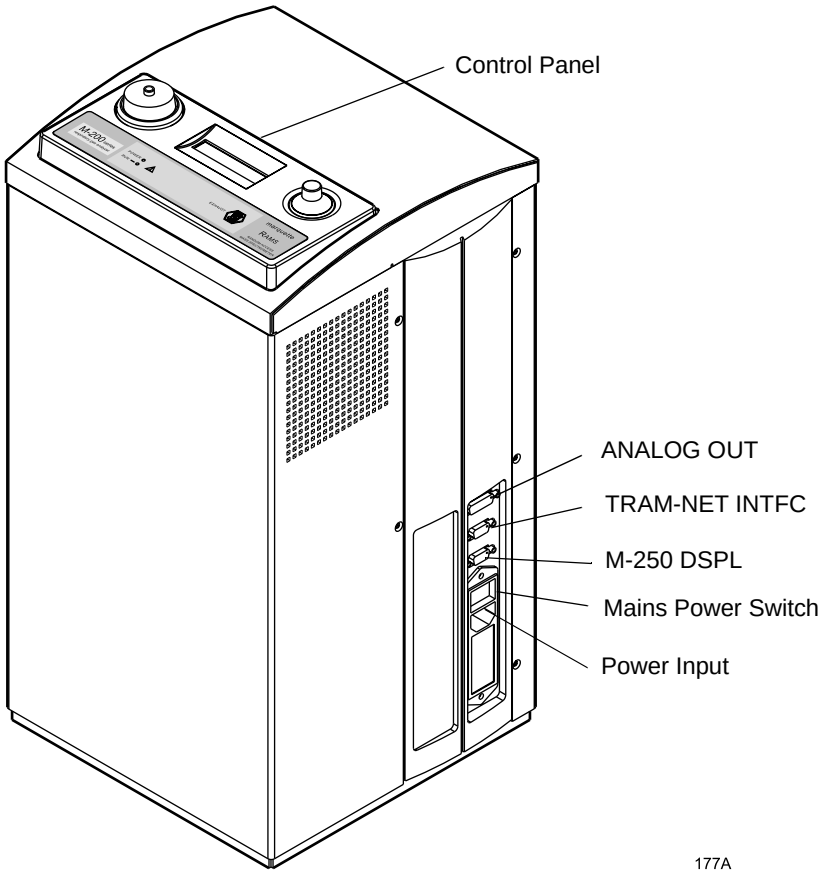
RAMS M-200

Introduction

The RAMS M-200 is intended to be used in an operating room setting for the analysis and display of inspired and expired gases. The following is a list of gases the RAMS M-200 recognizes and the labels used to identify each on the monitor's display:

Oxygen (O2)
Carbon dioxide (CO2)
Nitrogen (N2)
Nitrous oxide (N2O)
Enflurane (ENF)
Halothane (HAL)
Isoflurane (ISO)
Desflurane (DES)
Sevoflurane (SEV)

The Solar 9500 information monitor displays the data measured. The gas information is displayed with all other vital sign information (ECG, pressure, etc.), giving you a better profile of the total patient condition. All patient status alarms are on the monitor, allowing you immediate recognition of a violated parameter. Assessments of the respiratory system in anesthesia can be made with the help of information from the other monitored parameters, and a record can be made.



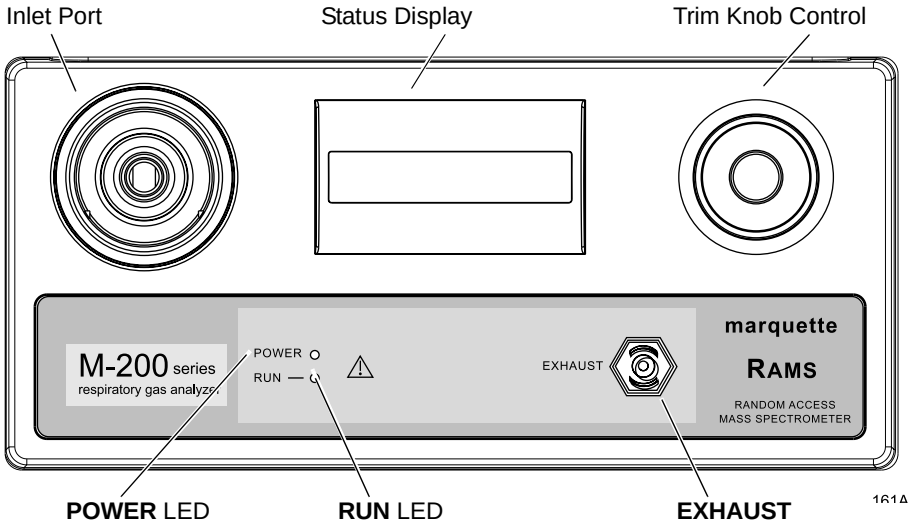
RAMS M-200

NOTE: To prevent loss of vacuum conditions if the unit is stored for prolonged periods of time, keep the RAMS unit's Mains Power Switch in the ON position (**I**).

Below is a list of features found on the RAMS M-200:

Control Panel	Used for selecting and displaying the menu selections and status of the unit; also contains the gas inlet.
ANALOG OUT	Used for analog gas signals.
TRAM-NET INTFC	Connect here to transfer data between the RAMS M-200 and a monitor.
M-250 DISPL	Connect here to transfer data between the RAMS and a M-250 Display.
Mains Power Switch	Used to apply power to the RAMS. Press the **I** side of the switch to turn power ON, or press the **O** side to turn power OFF.
Power Input	Used for power inlet; also contains Mains Power Switch, fuse block, and voltage selector card.

RAMS M-200 Control Panel Features



RAMS M-200 Control Panel

Below is a list of features found on the RAMS Control Panel:

Trim Knob Control	The RAMS Trim Knob control is for service use only. The RAMS Trim Knob control is disabled when connected to an operating monitor.
EXHAUST	Exit port for sampled gas.
Status Display	LCD display for status, diagnostic and data.
Inlet Port	Inlet port for installing the Aqua-Knot water trap.
RUN LED	Displays yellow when in Start-up mode or Standby mode, displays green when in Run mode.
POWER LED	Displays green when power is applied to the RAMS.

Safety Information

Be sure to read all of the following safety information before monitoring a patient with the RAMS M-200 system.

WARNING

GAS MIXTURES—The RAMS M-200 system is designed to analyze gas mixtures consisting of oxygen, nitrogen, nitrous oxide, carbon dioxide, desflurane, enflurane, halothane, isoflurane, and sevoflurane. Each gas concentration is displayed as a percentage of the total measurable gases. Introduction of any other gas(es) into the sample (e.g., helium) will cause the displayed data to be incorrect. Do not rely on the displayed data if this situation occurs.

CAUTIONS

ANESTHETIC AGENT VERIFICATION—When administering anesthetic agents, always verify your anesthetic vaporizer settings.

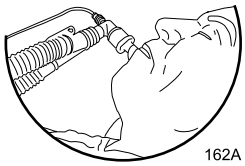
AQUA-KNOT WATER TRAP—An Aqua-Knot water trap must always be used when the RAMS is connected to a patient. Failure to use the water trap can result in contamination of the equipment and may cause subsequent inaccurate gas analysis data.

Replace and dispose of the Aqua-Knot water trap when occluded. Do not reuse. Reusing the water trap may cause incorrect readings to be displayed and may damage the equipment.

CONTAMINANT PREVENTION—Always keep an Aqua-Knot water trap or filter on the RAMS gas sample inlet when not in use. This will prevent dust from being drawn into the system, which may damage the equipment.

SAMPLE RATE—The RAMS sampling rate from the patient airway is not adjustable. Do not use on any patient whose minute volume cannot tolerate a negative flow rate of 250 cc/min.

NOTE:



Always position the Luer-Lok connection and patient sample line in an upright position to avoid aspiration of fluids into the patient sample line, which will cause premature blockage of the Aqua-Knot water trap.

Insure that all connections are tight and verify leak-free connections by sampling with 100% O2. Allow the O2 readings to stabilize, then check that an O2 reading of 99% or greater is achieved.

Delivery of bronchodilators, mucolytics via aerosol, and meter dose inhalers will cause premature blockage of the Aqua-Knot water trap. Discontinue gas analysis prior to treatment by placing the unit into standby and removing the airway adapter from the ventilator circuit, or disconnecting the sample line from the Aqua-Knot water trap.

Setup

RAMS M-200 System Connection

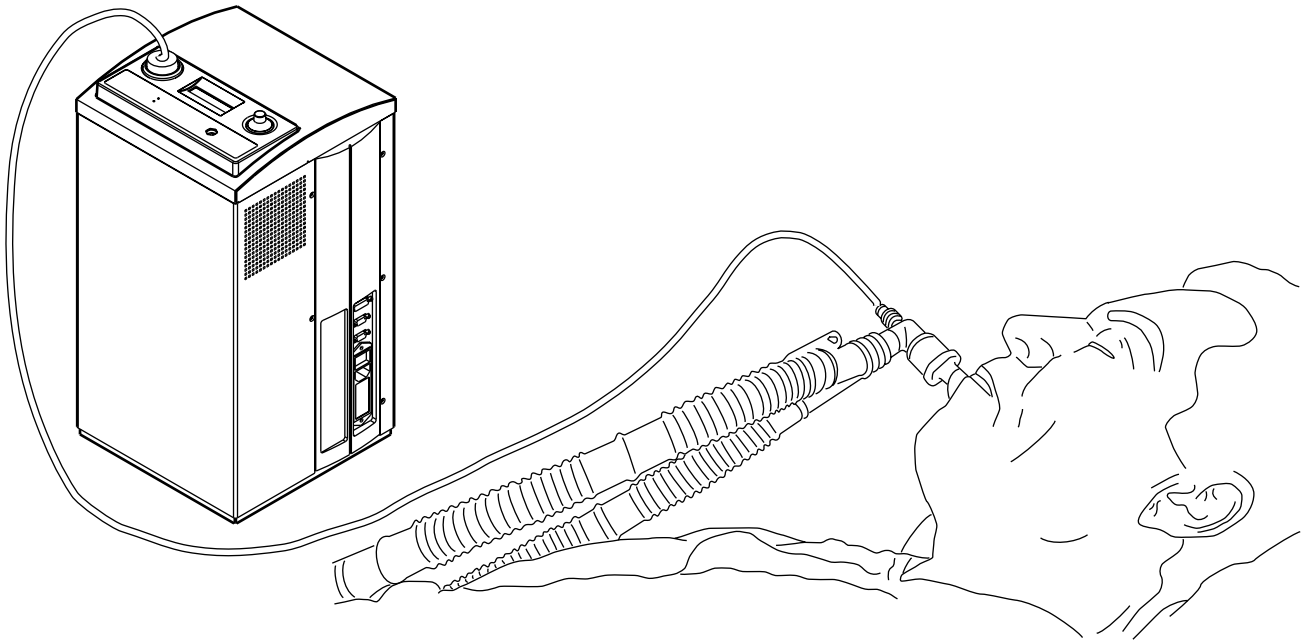
The RAMS M-200 connects to the monitor via port 1 or 2 on the side of the processor unit. For more information on connecting the monitor to a RAMS unit, refer to the service manual.

Locate the Mains Power Switch on the side of the RAMS unit and apply power to the RAMS by pressing down on the **I** side of the switch.

NOTE: To prevent loss of vacuum conditions when the unit is stored for prolonged periods of time, keep the RAMS unit's Mains Power Switch in the ON position (**I**).

When power is applied, both the POWER and RUN LEDs will come on and the RAMS will begin its start-up sequence. After a few seconds the RUN LED will go out and remain out for about 15 seconds. Next the RUN LED will flash yellow for about 15 seconds to indicate STANDBY mode. When start-up is successfully completed the RUN LED will turn green to indicate RUN mode, and will remain on. This sequence checks the entire system before any gas collection can occur. The RAMS is now in the RUN mode and ready to begin sampling.

Patient Connection



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RAMS M-200 Patient Connection

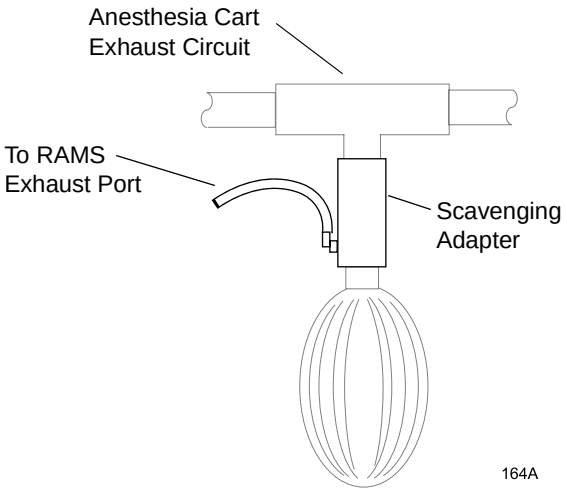
Patient connection consists of connecting the gas sampling line from the patient's proximal airway to the RAMS gas sample inlet port via the Aqua-Knot water trap. The RAMS draws the patient sample through the sample line, through the Aqua-Knot water trap, and into the RAMS to be analyzed.

The analyzed data is processed and then displayed on the screen of the monitor.

NOTE: For non-intubated patients, a sampling nasal cannula can be used. The Aqua-Knot water trap must be used.

Gas Exhaust

The gas exhaust may be scavenged using the exhaust set (pn 9504-016), included with each RAMS M-200.



Follow the steps listed below to properly connect the RAMS M-200 to an anesthesia cart exhaust circuit.

CAUTION
Do NOT connect exhaust of the RAMS to an unregulated high vacuum source. Vacuum may cause inaccurate gas readings and also may cause serious damage to the equipment's internal components.

1. Remove exhaust adapter and line from the package.
2. Attach connector end of the exhaust line to the outlet marked **EXHAUST** on the control panel of the RAMS M-200.
3. Install exhaust line into gas scavenging system of anesthesia delivery system of anesthesia delivery system following anesthesia machine manufacturer's recommended procedure.
4. Drape exhaust line so that it does not obstruct work area.

CAUTION
Do NOT allow the exhaust line to become kinked or blocked. Back pressure may cause inaccurate gas readings and also may cause serious damage to the equipment's internal components.

Checklist

1. An Aqua-Knot water trap is inserted in the RAMS.

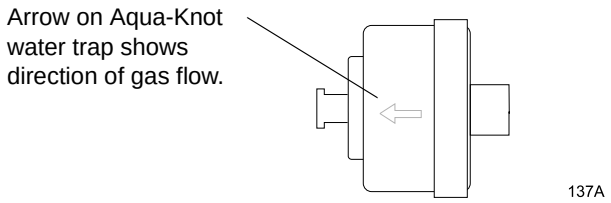
   NOTE: The arrow on the Aqua-Knot water trap shows the direction of the gas flow. Connect with arrow facing the RAMS.

2. Patient sample line is correctly positioned in respiratory circuit and to the Aqua-Knot water trap.
3. Scavenging line is connected to **EXHAUST** connector on RAMS.
4. All components have power on.
5. Make adjustments as necessary using the *CO2 Controls* window and the *GAS Controls* window.

If you suspect a RAMS failure, call service.

Aqua-Knot Water Trap

User Information



Aqua-Knot Water Trap

Insert an Aqua-Knot water trap into the Inlet Port and turn it clockwise until snug. Do NOT overtighten.

CAUTIONS

AQUA-KNOT WATER TRAP—An Aqua-Knot water trap must always be used when the unit is running. Failure to use the water trap can result in contamination of the internal gas measurement instruments and may cause subsequent inaccurate gas analysis data.

REPLACEMENT—Replace and dispose of the Aqua-Knot water trap weekly or when occluded, whichever occurs first. Do not reuse. Reusing the water trap may cause incorrect readings to be displayed and may damage the equipment.

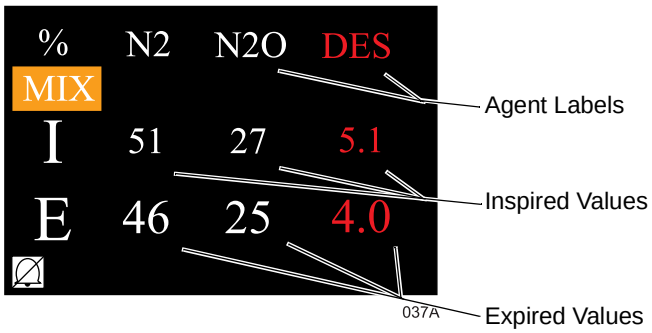
CONTAMINANT PREVENTION—Always keep an Aqua-Knot water trap or filter on the gas sample inlet when not in use. This will prevent dust particulates from being drawn into the system, which may damage the equipment.

NOTE: Delivery of bronchodilators, mucolytics via aerosol, and meter dose inhalers will cause premature blockage of the Aqua-Knot water trap. Discontinue gas analysis prior to treatment by placing the unit into standby. Remove the airway adapter from the ventilator circuit, or disconnect the sample line from the Aqua-Knot water trap.

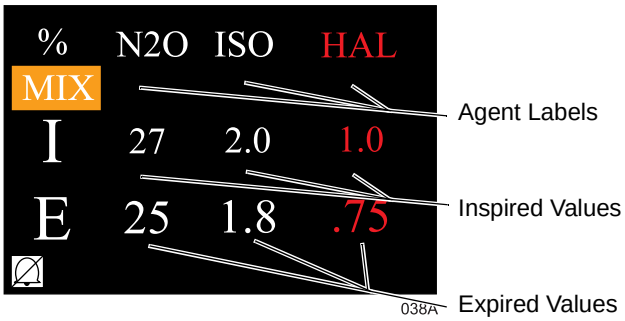
Gas Monitoring

Parameter Window Displays

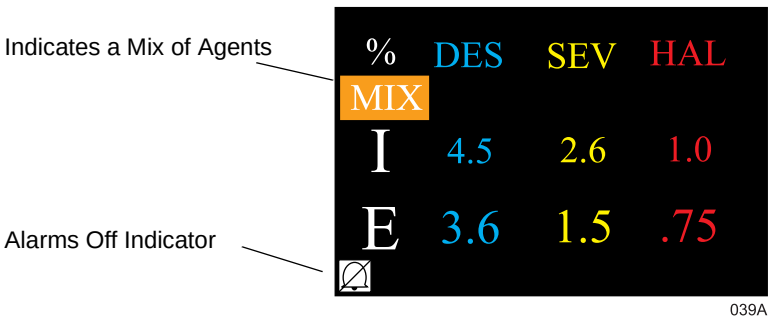
When all connections are made and the SAM module or RAMS M-200 has warmed up, CO2 and GAS parameter windows are displayed on the monitor's screen. (See the figures below.)



GAS Parameter Window — Default View (RAMS Unit)



GAS Parameter Window — Default View (SAM Module)



GAS Parameter Window — Other View (RAMS Unit or SAM Module)

These values are obtained from the SAM module or the RAMS M-200 system. If more than one anesthetic agent is detected, a *MIX* message appears in the GAS parameter window.

MIX Defaults — RAMS Unit

With the RAMS unit as acquisition source for gas monitoring information, if the GAS view is set to *Default*, the GAS parameter window displays inspired (I) and expired (E) N2, N2O, and the predominant anesthetic agent, for example, Halothane.

MIX Defaults —SAM Module

With the SAM module as acquisition source for gas monitoring information, if the GAS view is set to *Default*, the GAS parameter window displays inspired (I) and expired (E) N2O, and the two predominant anesthetic agents, for example, Isoflurane and Halothane.

MIX — Other

If the GAS view is set to *Other*, the GAS parameter window displays inspired (*I*) and expired (*E*) values for the three predominant anesthetic agents.

Colors

All gas parameter have fixed colors that may not be changed. The globally accepted colors are used:

Gas	Color
Desflurane	Blue
Halothane	Red
Enflurane	Amber
Isoflurane	Magenta
Sevoflurane	Yellow
N2 and N2O	White

Breath Display (RAMS Unit)

Breath display mode occurs as soon as breaths are detected from the patient. In breath display mode, the inspired and expired concentrations are updated at the end of each breath, along with respiratory rate.

If no breaths are detected for twenty seconds, the respiratory rate and expired CO2 concentration are displayed as zero. When this occurs, all other expired values are marked as invalid (*X*). After five minutes of no breath detection, the system enters a continuous display mode.

Continuous Display (RAMS Unit)

In continuous display mode, the inspired concentrations (*I*) are updated in real time with the current sampled concentrations. The expired (*E*) concentrations and the respiratory rate are marked invalid (*X*). The system enters continuous display mode after power up or after five minutes of no breath detection and continues until breaths are detected.

Automatic Shutdown (RAMS Unit)

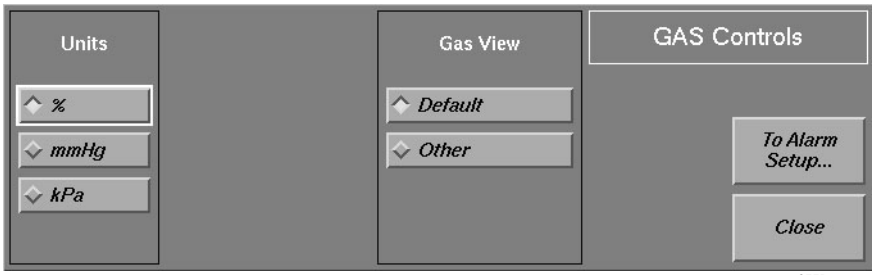
Refer to “Run Mode” in the RAMS Unit section of Chapter 17, CO2 Monitoring, for a description of the RAMS unit standby operation.

Automatic Shutdown (SAM Module)

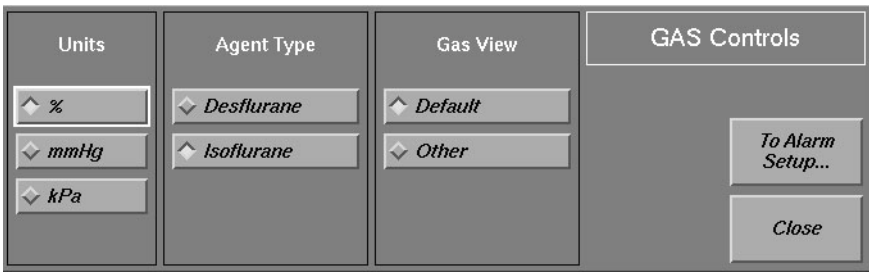
Refer to “Run Mode” in the SAM Module section of Chapter 17, CO2 Monitoring, for a description of the SAM module standby operation.

Gas Controls Window

Selecting *GAS…* from the *Respiratory* popup menu opens the *GAS Controls* window. The *GAS Controls* window can also be opened by touching or clicking on the GAS parameter window.



***GAS Controls* Window — RAMS unit**



***GAS Controls* Window — SAM module**

Units

This option allows you to choose units of measure for gas parameters. The choices are *%*, *mmHg*, and *kPa*. The default unit is *%*.

Agent Type

This option tells the monitor which agent combination to analyze. The two agent combinations are:

ISO—*Isoflurane*, halothane, enflurane, and sevoflurane

DES—*Desflurane*, halothane, enflurane, and sevoflurane

NOTE: The Agent Type controls are only available when using SAM modules.

Gas View

If a mix has occurred which takes down the N2 and N2O values, select *Default* to redisplay the N2 and N2O values and the predominant agent.

NOTE: RAMS Unit only. The SAM module does not detect N2.

To return to the default or previously viewed gas parameter window, select *Other*.

GAS Controls

The *GAS Controls* also offers buttons which open/activate other related areas/functions. These buttons are:

To Alarm Setup...

Close

Gas Mixtures

SAM Module

NOTE: Halothane and enflurane are identified and quantified in a mixture with desflurane if desflurane is less than 7%.

CAUTION

ISOFLURANE AND DESFLURANE—The SAM module cannot distinguish between isoflurane and desflurane. You must use an option in the *GAS Controls* window (*Agent Type: Isoflurane/Desflurane*) to tell the module which agent combination will be used.

If both are present (i.e., when introducing one and discontinuing the other) inaccurate values are displayed for the selected agent (isoflurane or desflurane) until only the selected agent is present. If Isoflurane is selected and concentration is greater than 5.0%, "*Desflurane?*" prompt will be displayed suggesting verification of correct selection.

When a mixture of anesthetic agents is detected, the label *MIX* will be displayed in the GAS parameter window. The criteria for a gas mixture is two or more anesthetic agents, each greater than 0.30% in concentration. A third agent will be displayed if its concentration is greater than .60%. The mix label remains until all but one anesthetic agent is less than 0.1% concentration. (EXCEPTION: The removal threshold for halothane is 0.15% concentration.)

If two agents are detected, the primary and secondary agents are displayed with N2O. The primary agent is always displayed on the left. (Primary agent is defined as the agent with the greatest inspired value.)

If a third agent is detected with a concentration greater than 0.60%, the N2O values will be removed to make room for the third agent. Using a software menu option, you can request that the N2O values be redisplayed with the primary and secondary agents. (Refer to Gas View in this chapter.)

RAMS

When a mixture of anesthetic agents is detected, the label *MIX* will be displayed in the GAS parameter window. The criteria for a gas mixture is two or more anesthetic agents, each greater than 0.15% in concentration. The message remains until all anesthetic agents are at less than 0.1% concentration except one.

Troubleshooting

Messages

Following is a list of some of the messages that may appear on the monitor when monitoring anesthesia gases. Message text appears in bold type, and the acquisition source is listed in parentheses.

A message should clear when normal operating criteria are met or a solution is found. If a message persists, call service.

NOTE: The actual message that appears on your monitor depends on the module being used and the installed software version.

Blocked Line (SAM module, RAMS unit)

Cause: Sample line or exhaust line is blocked.
Solution: Check sample and exhaust lines for blockage.
Replace Aqua-Knot water trap.

Calibrate (SAM module, RAMS unit)

Cause: Acquisition source is out of calibration.
Solution: Calibrate SAM module or call for RAMS service.

Calibrate RAMS (RAMS unit)

Cause: RAMS calibration interval timer is in alarm, or RAMS is out of calibration.
Solution: Calibrate RAMS.

Calibration Mode (SAM module)

Cause: User has entered the SAM module calibration service procedure.
Solution: Exit to continue monitoring.

Change Module Cell (SAM module)

Cause: SAM service error.
Solution: Call service.

Desflurane? (SAM module)

Cause: You are delivering Desflurane, but Isoflurane is selected.
Solution: Select *Desflurane* from the *Agent Type* controls in the *GAS Controls* window.

Isoflurane? (SAM module)

Cause: You are delivering Isoflurane, but Desflurane is selected.
Solution: Select *Isoflurane* from the *Agent Type* controls in the *GAS Controls* window.

Communication Error (RAMS unit)

Cause: RAMS unit service error.
Solution: Call service.

Connect Aqua Knot (SAM module, RAMS unit)

Cause: Aqua-Knot is missing.
Solution: Connect Aqua-Knot water trap.

Connect Cable/Device Off? (RAMS unit)

Cause: RAMS unit power is off, or there is no cable connection.
Solution: Turn the RAMS unit on, or check cable connections.

Gas Liquefied (SAM module)

Cause: Gas cells have liquefied.
Solution: Apply power, wait for module to warm up (30 minutes to 1 hour).

Gas Liquefied/Warming Up (SAM module)

Cause: Due to extreme temperature change, gas in one or more internal cells has liquefied.
Solution: Apply power and wait for module to warm (approximately 30 minutes).

Moisture Detected (RAMS unit)

Cause: RAMS unit detects moisture.
Solution: Call service.

No Breath Detected (SAM module, RAMS unit)

Cause: No breath detected or sampling line is disconnected from patient airway.
Solution: Check the patient and all patient connections.

Remove Aqua-knot (SAM module, RAMS unit)

Cause: Aqua-knot water trap was not removed before calibration.
Solution: Remove Aqua-Knot water trap (SAM), call service (RAMS).

Room Air Cal in Progress (SAM module)

Cause: Air cal in progress.
Solution: Normal operation continues when message clears.

Service Mode (SAM module, RAMS unit)

Cause: User has entered the service mode.
Solution: Exit to return to monitoring.

Service… messages (SAM module, RAMS unit)

Cause: Hardware failure.
Solution: Call service.

Unknown Error (SAM module)

Cause: Unknown SAM module CO2 error.
Solution: Call service.

Warming Up (SAM module, RAMS unit)

Cause: Appears whenever a SAM module is placed in a Tram-rac and when the RAMS unit is in warm-up mode.
Solution: Message will clear when warmed up. If it persists beyond 4 minutes, call service.

For your notes

19 Interfaces

For your notes

Introduction

The monitor can interface with other manufacturers' peripheral bedside devices, such as ventilators and gas delivery systems, to centralize patient data on one device. A Unity Network ID is used with the monitor to communicate with peripheral devices.

IMPORTANT: The monitor can only display information that the peripheral device sends. The parameters sent vary with each peripheral device and are subject to change without notice by the manufacturer of the device.The following chart shows the compatible peripheral devices at the time this manual was published. This table is organized by device type.

Device Connectivity Chart

Device Type	Manufacturer and Model	Waveforms	Alarms
Anesthesia machine	**Dräger Julian**	Pressure, CO2	Yes
Anesthesia machine	**Dräger Cato, PM 8050**	Pressure, CO2	Yes
Anesthesia machine	**Dräger Cicero EM**	Pressure, CO2	Yes
Anesthesia machine	**Dräger PM 8060**	Pressure, CO2	Yes
Anesthesia machine	**North American Dräger Narkomed 2B, 2C, 3, 4, GS, 6000**	2C/4: Pressure, Flow 4 only: CO2 GS: Pressure	Yes
Anesthesia machine	**Ohmeda 7800, 7810**	None	Yes
Anesthesia machine	**Ohmeda 7900**	None	Yes
Anesthesia machine	**Ohmeda Aestiva 3000**	None	Yes
Continuous cardiac output	**Abbott Q-Vue**	na	Status messages only
Continuous cardiac output with SVO2	**Abbott Q-2**	na	Status messages only
Continuous cardiac output with SVO2	**Baxter Edwards Vigilance**	na	Yes
Gas analyzer	**Datex Capnomac Ultima**	None	Yes
Gas analyzer	**Ohmeda 5250 RGM**	None	Yes
Gas analyzer	**Ohmeda Rascal II**	None	No
Ventilator	**Allied Health Care Bear 1000**	Pressure, Flow	Yes

Device Connectivity Chart

Device Type	Manufacturer and Model	Waveforms	Alarms
Ventilator	**Bird 6400ST, 8400ST**	None	Yes
Ventilator (neonatal)	**Bird VIP**	None	Yes
Ventilator (neonatal)	**Dräger Babylog 8000**	Pressure, Flow	No
Ventilator	**Dräger Evita**	Pressure	Yes
Ventilator	**Dräger Evita 2, Evita 2 Dura, Evita 4**	Pressure, CO2	Yes
Ventilator	**Hamilton Amadeus, Veolar**	Pressure, Flow	Yes
Ventilator	**Hamilton Galileo**	Pressure, Flow	Yes
Ventilator	**Nellcor Puritan Bennett Adult Star, Adult Star 1500, 2000**	None	Yes
Ventilator (neonatal)	**Nellcor Puritan Bennett Infant Star, Infant Star 500, 950**	None	Yes
Ventilator	**Nellcor Puritan Bennett 7200SPE, AE, E**	None	Yes
Ventilator	**Puritan-Bennett 840**	None	Yes, with the following exceptions: $\dot{V}_{E\ TOT}$ $V_{TE\ MAND}$ $V_{TE\ SPONT}$ $V_{TI\ SPONT}$
Ventilator	**Siemens SV900C, 900D, 900E**	None	No
Ventilator (adult/neonatal)	**Siemens SV300**	Pressure, Flow	Yes

Safety

WARNINGS

ACCURACY — Patient information transferred by a connectivity device to a clinical information system must be qualified by medical personnel before permanent storage in a database.

ALARMS — The peripheral device's alarms must not be turned off or the volume reduced in any way to diminish the importance of the peripheral device as the primary alarm source for parameters monitored by the peripheral device.

CORRECT ADAPTER — Use of the wrong interface adapter may cause improper operation of the supported peripheral device. Verify that the correct interface adapter on the peripheral device is operational before the device is used on a patient.

INSTALLATION — Qualified technical personnel must connect the interface adapter to the peripheral device and make any necessary adjustments to the peripheral device (baud rate, parity, etc.) as described in the specific installation instructions for the interface adapter.

Insert cabling from the connectivity device only into specified interface adapters and specified peripheral devices.

To avoid inadvertent disconnection, route all cables in a way to prevent a stumbling hazard. Wrap and secure excess cabling to reduce risk of entanglement by patients and personnel. Do not install in a location where the device may drop on a person.

SINGLE PATIENT USE — All eight serial ports of the connectivity device must only be used by one patient.

CAUTION

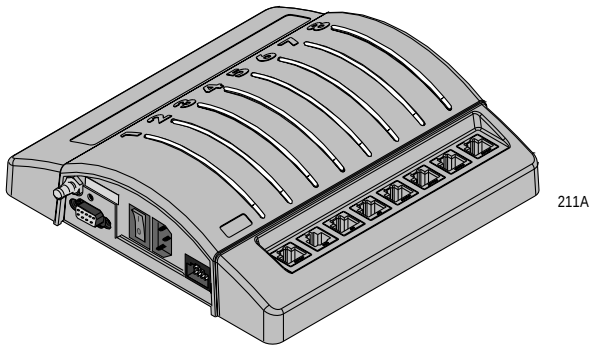
INSTALLATION — To avoid accidental ingress of liquids, always mount the connectivity device in a vertical position with the connectors at the bottom.

NOTE

To assure proper operation, we recommend that you permanently connect each interface adapter to each peripheral device that will communicate with the connectivity device.

Unity Network ID Connectivity Device

A Unity Network ID connectivity device can interface with up to eight different devices for one patient.

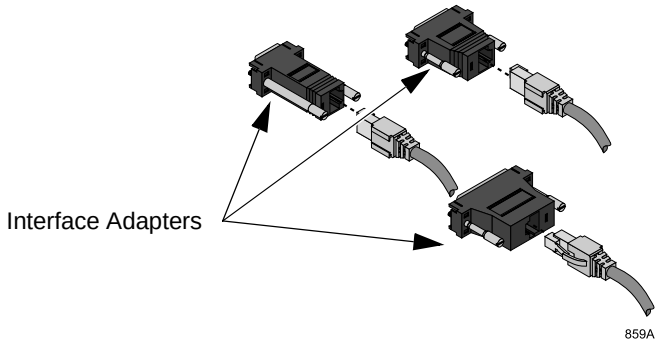


Unity Network ID Connectivity Device

Interconnection

The Unity Network ID connectivity device connects to the Solar 9500 monitor via one of the M-Port connectors on the processing unit. For complete system interconnection instructions, refer to the appropriate connectivity device operator and service documentation.

The connectivity device can interface with up to eight different peripheral devices for one patient. Each peripheral device connected to the connectivity device must use a special interface adapter that is factory programmed to allow communication between the two devices. Communication setup and installation instructions are provided with each interface adapter. Refer to these instructions for specific instructions regarding where the interface adapter is connected to the peripheral device, as well as any special settings needed to facilitate communication with the peripheral device.



Interface Adapters

Once the interface adapter is permanently connected to the peripheral device, the cable can be plugged into any one of the eight serial ports on the connectivity device.

Serial Port Indicator Lights

Each serial port on the connectivity devices has an indicator light located directly above it. This light is used to determine the status of the serial port.

Serial Port Indicator Light

Green State	Yellow State	Status	Description
Off	Off	No connection	Nothing is connected to the associated serial port or the interface connector is not operational.
	On	Communication pending	Cable and interface adapter are connected, but the supported device communication is not yet established.
	Slow blinking (once every 2 seconds)	Communications error	Connected, but communications error with supported device.
	Fast blinking (twice every second)	Other errors	Indicates: 1. Too many supported devices of one type are connected. 2. Interface adapter is malfunctioning. 3. Supported device software is not compatible with the monitor software. 4. Interface adapter is not supported by the monitor software.
On		Working	Communication with the supported device is good.

Displayed Data

The data from a peripheral device that is displayed at the monitor varies with each device. The chart below gives some general information as to what data is available to the monitoring system and how it is handled (trending, alarm broadcast, etc.). The Device Connectivity Chart at the beginning of this chapter has more detailed information regarding waveforms and alarms.

Peripheral Device Data and the Monitoring System

Peripheral Device Type	Waveforms[1, 3]	Parameter Windows	Trends	Alarm Broadcast[3]	Graphing
Ventilators	Yes	Yes	Yes	Yes	Yes
Anesthesia Machines	Yes	Yes	Yes	Yes	Yes
Gas Analyzers	Yes	Yes	Yes	Yes	Yes
Continuous Cardiac Output	No	Yes	Yes	Yes	Yes

[1]Unity Network ID support only digital waveforms.

[2]CIC version 1.0 and subsequent, Centralscope version 10B and subsequent.

[3]Refer to Device Connectivity Chart at the beginning of this chapter.

Parameters

As stated previously, the parameters displayed at the monitor from a peripheral device vary from device to device. Ventilators, gas analyzers, continuous cardiac output devices, and anesthesia machines are capable of sending a number of parameters to the patient monitor. In some cases, not all can be displayed at one time. To view a list of available parameters, look for a menu option such as *SELECT PARAMETERS* or *DISPLAY PARAMETER*. Select the menu option to open a popup list of the parameters that the peripheral device sends to the monitor. You can then select parameters for display from this popup list.

Parameter Windows and Menus

Examples of parameter windows and menus are shown below for the different device types. The data displayed in the parameter window may vary with each device. Not all menu options are available with all devices.

Ventilators

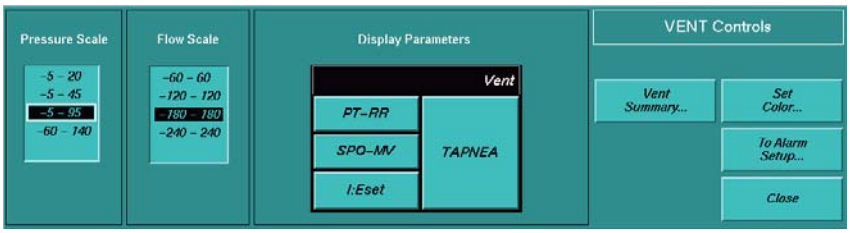
A parameter window labeled *VNT* is displayed for ventilators. The data displayed varies among ventilator devices. Use the parameter menu to change the parameters displayed.

NOTE

Some ventilators may also have a CO2 window and menu. Refer to the Gas Analyzers section in this chapter for this information.

213A

Ventilator Parameter Window



214A

Ventilator Parameter Menu

- *Pressure Scale*— Allows you to select a scale for the ventilator pressure waveform (centimeters of water).
- *Flow Scale*— Allows you to select a scale for the ventilator flow waveform (liters per minute).
- *Display Parameters*— Allows you to select parameters for display in the parameter window.
- *VENT Controls* —The *VENT Controls* window offers buttons which open/activate other related areas/functions. These buttons are:
  - *Vent Summary*,
  - *Set Color*, and
  - *To Alarm Setup*.

Anesthesia Machines

Up to three parameter windows and menus may appear on the monitor when interfacing with an anesthesia machine — CO2, GAS, and VNT.

Refer to the Ventilators section and the Gas Analyzers section in this chapter for examples of these parameter windows and associated parameter menus.

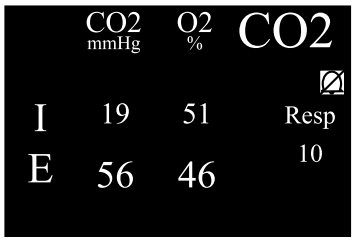
Gas Analyzers

Gas analyzers provide two parameter windows, one with CO2 information and the other with gas information. Each parameter window may have a parameter menu. The data in the parameter windows may be organized differently depending on the peripheral device connected.

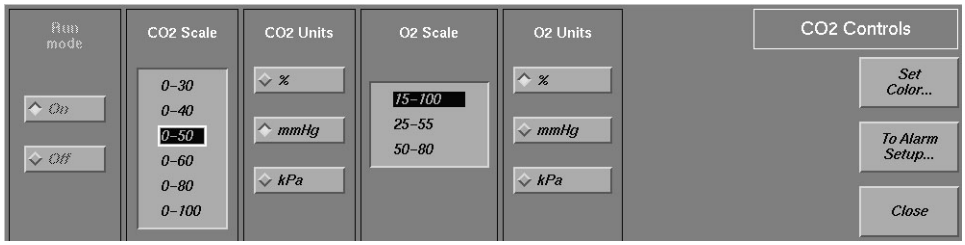
CO2 Parameter

NOTE

Only one CO2 parameter can be displayed at one time on the monitor. The monitor recognizes the first CO2 source and ignores any subsequent ones.



034A



CO2 Parameter Menu 218A

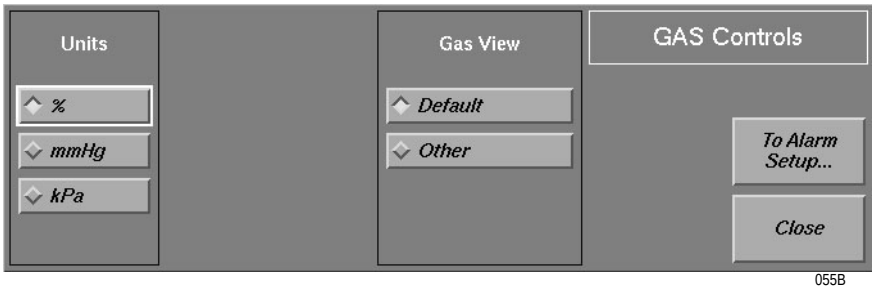
- *Run Mode*— Allows you to place the SAM module in standby mode by selecting *Off*. If the SAM module is present, *On* will be highlighted.
- *CO2 Scale* — Allows you to choose an appropriate scale for the displayed CO2 waveform.
- *CO2 Units* — Allows you to choose the unit of measure for inspired and expired CO2—*mmHg*, *%*, or *kPa* (kilopascals).

NOTE: The *O2 Scale*, *O2 Units*, *and O2 Compensation* options are NOT available when using the SAM 80 module.

- *O2 Scale*— Allows you to choose an appropriate scale for a displayed O2 waveform. The scale choices will be different depending on the units of measure being used.
- *O2 Units*— Allows You to choose the unit of measure for inspired and expired O2—*%*, *mmHg*, or *kPa* (kilopascals).
- *CO2 Controls* — The *CO2 Controls* window offers buttons which open/activate other related areas/functions. These buttons are:
  - *Set Color...*
  - *To Alarm Setup...*
  - *Close*

Gas Parameter

Gas Parameter Window



Gas Parameter Menu

- *Units* — Allows you to choose units of measure for the applicable parameter.
- GAS — If a mix has occurred which takes down the N2 and N2O values, select *Default* to redisplay the N2 and N2O values and the predominant agent. To return to the default or previously viewed gas parameter window, select *Other*.
- *GAS Controls* — The *GAS Controls* window offers buttons which open/activate other related areas/functions. These buttons are:
  - *To Alarm Setup...*
  - *Close*

Continuous Cardiac Output

A parameter window labeled *CCO* is displayed for these devices. There is also a CCO parameter menu.

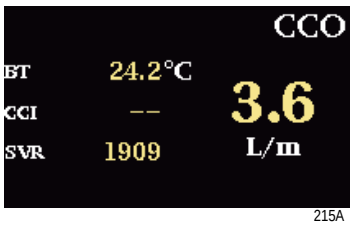
An additional SVO2 parameter window may be displayed with some continuous cardiac output devices. There is no parameter menu for this window.

NOTE

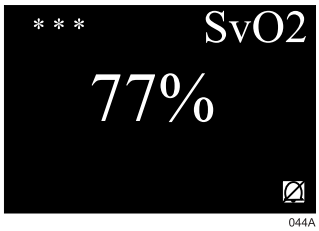
Only one SVO2 parameter can be displayed at one time on the monitor. The monitor recognizes the first SVO2 source and ignores any subsequent ones.

NOTE

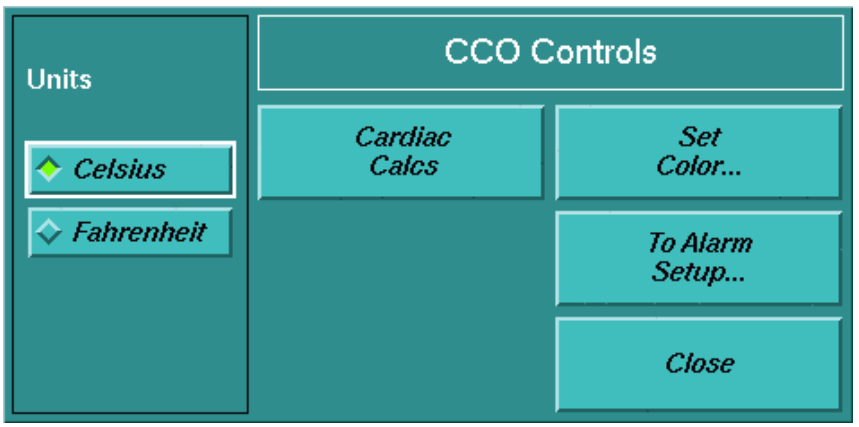
Asterisks are displayed to indicate signal strength. Three asterisks indicate a good signal, two indicate an average signal, and one indicates a weak signal. The signal strength asterisks for the CCO parameter may not be available with all devices.



CCO Parameter Window



SVO2 Parameter Window



CO2 Parameter Window

- *UNITS* — Select Celsius or Fahrenheit as the units of measure for blood temperature (*BT*).
- *CCO Controls* — The *CCO Controls* window offers buttons which open/activate other related areas/functions. These buttons are:
  - *Cardiac Calcs* — Enters the cardiac calculations program.
  - *Set Color*,
  - To Alarm Setup, and
  - *Close*.

Software Compatibility

Each Unity Network ID cable interface adapter is developed with specific peripheral device software. This software information is found on the installation instructions that accompany the adapters.

If you are going to upgrade the software for a peripheral device that already interfaces with an Unity Network ID device, please fill out a copy of the Notification of Equipment Upgrade and fax it to GE Medical Systems *Information Technologies*. (This form is found at the end of this chapter.) This is necessary to assure continued compatibility between the peripheral device and GE Medical Systems *Information Technologies* equipment.

Device-Specific Information

Siemens Servo 900C/D/E Ventilators

Be aware that when the ventilator is set to infant mode, the MV data it sends is 10 times greater than the actual value.

Notification of Equipment Upgrade

Software Compatibility

If you are going to upgrade another manufacturer's equipment that already interfaces with a GE Medical Systems *Information Technologies* patient monitor through an connectivity device, please photocopy this page, fill out all the information and fax it to:

GE Medical Systems *Information Technologies*
Milwaukee, Wisconsin U.S.A.
Attn: Customer Satisfaction
Quality Assurance Department
414-362-2585

We will call the contact person designated below to get the necessary information to determine whether your GE Medical Systems *Information Technologies* equipment will still be compatible with the upgraded equipment.

_____
Contact Person (Please PRINT Name) at Your Hospital/Institution

_____
Phone Number of Contact Person (Include Area Code and Extension)

_____
Hours When Contact Person Can Be Reached

_____
Name of Hospital/Institution

_____

_____
Address of Hospital/Institution (Include Country)

_____
Peripheral Equipment Manufacturer and Model Name

For GE Medical Systems *Information Technologies* Use:

Forwarded to Monitoring Marketing on _____

For your notes

Appendix A – Analog Output

For your notes

Tram Acquisition Modules

The configuration for the analog output from the Tram acquisition modules is detailed below. Analog output is obtained through the Defib Sync connector on the front of the appropriate module.

ECG Analog Output

Top displayed lead including augmented leads. If pace is on there is an enhanced pacer pulse (5 volts at 2 milliseconds) when pacemaker triggering is detected.

In the event of a LEAD FAIL, refer to the following:

Lead Failed	ECG Analog Out
RA	III
LA	II
LL	I
V	II
RL	Buzz*

* An RL lead fail causes an all *Leads Fail* on the screen and a buzz is output.

NOTE:

1. All ECG outputs are 1 volt per millivolt Referred To Input.
2. In single lead mode, if the specified lead is not available, a buzz will be output.
3. The ECG Analog Output is affected by the ECG filter setting, but not by the ECG gain setting.

BP Analog Output

BP analog output is only available with the Tram modules with the BP monitoring feature.

NOTE: A buzz will be sent to the analog out if the BP is not zeroed.

- The pressure labeled ART (BP 1-4) is sent to the analog out.
- If two or more pressures are labeled ART, for example, BP-3 and BP-4, the first (BP-3) will be sent to the analog out.
- If all the BPs are labeled ART, then BP-1 will be sent to the analog out.
- If there is no pressure labeled ART, then BP-1 will be sent to the analog out.

All BP outputs are 10 mV/mmHg when zeroed.

Digital Synchronization Output

A digital sync output is available with a return marker on those modules with the defib sync feature. (Refer to the module's service manual for specifications.)

Tram-rac Housing

The analog output from the Tram-rac housing provides the following signals when using the analog output cable. (Refer to the service manual for the specific pin configuration.)

NOTE: Refer to Chapter 1, Tram-rac Housing section, for location of the analog output connectors on the various housings.

NOTE: ECG Analog Output is affected by the ECG filter setting, but not by the ECG gain setting.

ECG Analog Output

Top displayed lead including augmented leads.

In the event of a LEAD FAIL, refer to the following:

Lead Failed	ECG Analog Out
RA	III
LA	II
LL	I
V	II
RL	Buzz*

* An RL lead fail causes an all *LEADS FAIL* on the screen and a buzz is output.

ECG lead II (Buzz if lead II fail)

ECG lead V (Buzz if lead V fail)

All ECG outputs are 1 volt per millivolt Referred To Input.

BP Analog Output

NOTE: For BPs coming from a Tram module, a buzz will be sent to the analog out if the BP is not zeroed. If the BP source is other than a Tram module, a non-zeroed waveform is displayed. A zero procedure must be performed to display actual BP data. All BP outputs are 10 mV/mmHg when zeroed.

- First ART or BP1 if no ART monitored
- BP2 or SPO2 waveform (if available) if BP2 is not present
- BP3 or SPO2 value (if available) if BP3 is not present
- BP4 or Resp waveform (if available) if BP4 is not present
- Waveform in slot #5 (Tram-rac housings with 3 or more slots)
- Waveform in slot #6 (Tram-rac housings with 3 or more slots)
- Waveform in slot #7 (Tram-rac 4A housing only)
- Waveform in slot #8 (Tram-rac housings with 3 or more slots)

For your notes

Appendix B – Battery Information

For your notes

Ni-Cd Battery Specifications

The battery is used to keep the Solar 9500 CPU/hard drive functional for a period of time after power is interrupted. If input power is interrupted beyond that time, the CPU will begin an orderly shutdown of the unit. The period is determined by the calculated charge of the battery and the voltage under load. The maximum period allowed is 12 seconds.

The battery pack consists of 11 Sanyo N-800AR nickel-cadmium cells.

NOTE: The electrical connector of the internal battery is mechanically polarized to insure only proper connection. Do not force improper connection.

Battery Pack Specifications

Parameter	Min	Typ	Max	Units	Notes/Conditions
Battery Voltage	12.0	13.2	16.5	V	
Battery Capacity	575	700		mA-Hr	min @ high discharge rate
Charge Current		27		mA	continuous trickle charge
Discharge time		7.5		minutes	@ 4.9 amp drain rate (max battery load)
Charge time		80		hours	Charging a fully discharged battery

Battery Protection Specifications

Parameter	Protection	Notes/Conditions
Reverse Voltage	Polarized Plug	
Overcharge	Safety vent on each cell	The trickle charge current is resistance limited.
Over-discharge	Low voltage cutout	
Excessive drain rate	PTC thermal cutout	
Cell reversal	Voltage monitor top and center of the pack	
Over-temperature	PTC thermal cutout	

Recycling Information

The EPA certified RBRC Battery Recycling Seal on the nickel-cadmium (Ni-Cd) battery indicates GE Medical Systems *Information Technologies*, Inc. is voluntarily participating in an industry program to collect and recycle these batteries at the end of their useful life, when taken out of service in the United States or Canada. The RBRC program provides a convenient alternative to placing used Ni-Cd batteries in the trash or the municipal waste stream, which may be illegal in your area. Please call 1-800-8-BATTERY for information on the Ni-Cd battery recycling and disposal bans/restrictions in your area. GE Medical Systems *Information Technologies*' involvement in this program is part of our commitment to preserving out environment and conserving natural resources.

Appendix C – Supplies

For your notes

To ensure patient safety, use only supplies manufactured or recommended by GE Medical Systems *Information Technologies*. Your local sales representative can provide current supplies lists or you can contact GE Medical Systems *Information Technologies* Supplies. (Refer to “How to Reach Us” at the front of this manual.)

For your notes

Appendix D – Abbreviations and Symbols

For your notes

Abbreviations

	A
A	amps
AaDO2	alveolar arterial oxygen gradient
ABG	arterial blood gas
AC	alternating current
ACCV	accelerated ventricular
ACC VENT	accelerated ventricular
ACI	acceleration index
ADT	adult
AHA	American Heart Association
ALRM	alarm
AMP	amplitude, ampere
ANT	anterior
AO2 (aO2)	arterial oxygen saturation
AR	argon, arterial
ARR	arrhythmia
ART	arterial
Async	asynchronous
ASYS	asystole
Auto, AUTO	automatic
a–vO2	arterial venous oxygen content difference
AVF	left foot augmented lead
AVG	average
AVL	left arm augmented lead
AVR	right arm augmented lead
	B
Baro	barometric pressure
BE	base excess
BEecf	base excess extracellular fluid
BEb	base excess blood
BGMY	bigeminy
BIS	bispectral index
BP	blood pressure
BPM	beats per minute

BRAD	bradycardia
BSA	body surface area
BT	blood temperature

C

C	Celsius
CAL	calibration
CALC	calculation
CALCS	calculations
CaO2	arterial oxygen content
CARD	cardiac
CC	computation constant
cc, CC	cubic centimeter
CCI	continuous cardiac index
CCO	continuous cardiac output
CCU	critical care unit
CDYN	compliance dynamic
CEd	effective dynamic compliance
CH	channel
CI	cardiac index
cm, CM	centimeter
CO	cardiac output, carbon monoxide
CO2	carbon dioxide
COHb	carboxyhemoglobin
COMM	communication
COMP	compliance
CP	cardiopulmonary
CPLT	couplet
CPP	cerebral perfusion pressure
CPU	central processing unit
CRG	cardiorespirogram
CRT	cathode-ray tube
CS	central station
CSA	compressed spectral array
CvO2	mixed venous oxygen content difference
CVP	central venous pressure

D

D	diastolic
dB	decibel
DC	direct current
DC	discontinue
DDW	Direct Digital Writer
DEFIB, Defib	defibrillator
DES	desflurane
DIA	diastolic
DISCH	discharge
DIV	division
DSA	density modulated spectral array
DSC	digital signal converter
dyn	dyne

E

E	expired
ea–vO2	estimated arterial venous oxygen content difference
eCaO2	estimated arterial oxygen content
ECG	electrocardiograph
eCvO2	estimated mixed venous oxygen content
eDO2I	estimated delivered oxygen index
EEG	electroencephalograph
eg	for example
EMG	electromyograph
ENF	enflurane
eO2CI	estimated oxygen consumption
eO2R	estimated oxygen extraction ratio
eQs/Qt	estimated shunt fraction
Esopho	esophageal
ESU	electrosurgical cautery unit
et al	and others
EtCO2, ETCO2	end-tidal carbon dioxide
ETO	Ethylene Oxide
EX, Exp	expired
EXT	external

	F
F	Fahrenheit
FEM	femoral
FiO2	fraction of inspired oxygen
FR	French (catheter size)
	G
g	gram
GE	General Electric
Gluc	glucose
GTT/CC, gtt/cc	drops per cubic centimeter
	H
HAL	halothane
Hb	hemoglobin
HbO2	oxyhemoglobin
HCO3	bicarbonate
Hct	hematocrit
HE	helium
Hgb	hemoglobin
HIS	hospital information system
HR	heart rate, hour
HT	height
Hz	hertz
	I
I	inspired
IABP	intra-aortic balloon pump
iCa	ionized calcium
iCa (N)	ionized calcium normalized to pH 7.4
ICG	impedance cardiography
ICP	intracranial pressure
ICU	intensive care unit
ie	that is
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electrotechnical Commission
IN	inspired
Inc	incorporated
INF	infusion, inferior
INIT	initialization

Inj, INJECT	injectate
Insp	inspired
I-PEEP	intrinsic positive end expiratory pressure
IRRG	irregular
ISO	isoflurane
ISU	inlet select unit
IT	injectate temperature
IV	intravenous
	K
K+	potassium
kg, KG	kilogram
kPa	kilopascal
	L
L	liter, left
LA	left arm, left atrial
LAN	local area network
LAT	lateral
LBS	pounds
LCD	liquid crystal display
LCWI	left cardiac work index
LD	lead
LED	light emitting diode
LL	left leg
LIS	laboratory information system
LVET	left ventricular ejection time
LVSWI	left ventricular stroke work index
	M
M	mean, minute
m	meter
MAP	mean arterial pressure
MAWP	mean airway pressure
MCG	micrograms
MedF	median frequency
MetHb	methemoglobin
MG	milligrams
M-INSP	measured inspiratory time
MIN, min	minute

mL	milliliter
MM, mm	millimeters
MM/S, mm/s	millimeters per second
MMHG, mmHg	millimeters of mercury
M-PEEP	measured positive end expiratory pressure
MRI	magnetic resonance image
MTR	motor
MUNITS	milliunits
mV	millivolt
MV	minute volume
MVm	mechanical minute volume
MVs	spontaneous minute volume
	N
N2	nitrogen
N2O	nitrous oxide
Na+	sodium
NBP	noninvasive blood pressure
NC	non-capture
NEO, Neo	neonatal
NICO	non-invasive cardiac output
NS	non-sense
	O
O2	oxygen
O2CI	oxygen consumption index
O2DI	oxygen delivery index
O2R	oxygen extraction ratio
O2sat	oxygen saturation
O2set	oxygen setting
OR	operating room
oz	ounce
	P
PA	pulmonary artery
PaCO2	partial pressure of carbon dioxide in arterial blood
PAD	pulmonary artery diastolic
Pa/FiO2	oxygenation ratio
PAM	pulmonary artery mean pressure
PaO2	partial pressure of oxygen in arterial blood

PAO2	alveolar pressure
PAUS	pause
PAW, PAWP	pulmonary artery wedge pressure
PBAR	barometric pressure
PCO2, pCO2	partial pressure of arterial carbon dioxide
PCBF	pulmonary capillary blood flow
PEAKP	end inspiratory pressure
PED	pediatric
PEF	peak expiratory flow
PEEP	positive end expiratory pressure
PEEPi	intrinsic positive end expiratory pressure
PEP	pre ejection period
pH	hydrogen ion concentration
PIP	peak inspiratory pressure
pO2	partial pressure of oxygen
PO2	partial pressure of arterial oxygen
POC	point of care
PPLAT	plateau pressure
PT-RR	patient respiration rate
PULM	pulmonary
PVC	premature ventricular complex
PvO2	partial pressure of oxygen in mixed venous
PVR	pulmonary vascular resistance
PVRI	pulmonary vascular resistance index
PWR	power
	Q
QA	quality assurance
QRS	interval of ventricular depolarization
Qs/Qt	shunt fraction
QTY	quantity
	R
R	rate, right
RA	right arm, right atrial
RAM	random access memory
RAWe	resistance (airway) (expiratory)
REF	reference
RES	resistance

RESP	respiration
RF	radio frequency
RHb	reduced hemoglobin
RHY	rhythm
RL	right leg
RM	respiratory mechanics
RMT ALM	remote alarm
RMT VID	remote video
ROM	read-only memory
RR	respiration rate
RRm	mechanical respiration rate
RRs	spontaneous respiration rate
RTFC	artifact
RVSWI	right ventricular stroke work index

S

S	systolic
SaO2	arterial oxygen saturation
sec	second
SEF	spectral edge frequency
SI	stroke index
SOL	solution
SP	special
SPEC	spectrometer
SPO-RR	spontaneous respiration rate
SpO2	arterial oxygen saturation from pulse oximetry
SQI	signal quality index
SR	suppression ratio
STR	systolic time ratio
SUM	summation
SV	stroke volume
SvO2	mixed venous oxygen saturation
SVR	systemic vascular resistance
SVRI	systemic vascular resistance index
SYNC, Sync	synchronization
SYS	systolic

T

T1	temperature site 1
T2	temperature site 2
TACH	tachycardia
TC, Tc	transcutaneous
TCCO2, TcCO2	transcutaneous carbon dioxide
TCO2, TcO2	transcutaneous oxygen
TCO2	total carbon dioxide
Temp, TEMP	temperature
TFC	thoracic fluid content
TGMY	trigeminy
tHb (c)	total hemoglobin (calculated)
TMP, TP	temperature
TV	tidal volume
TVm	mechanical tidal volume
TVs	spontaneous tidal volume
TV-in	inspired tidal volume

U

UAC	umbilical artery catheter
UL	Underwriters Laboratories, Inc.
UO	uninary output
UVC	umbilical venous catheter

V

V	precordial lead
V	volt
VAC	volts AC (alternating current)
VBRADY	ventricular bradycardia
VBRD	ventricular bradycardia
VENT	ventilator
VEPT	volume of electrically participating tissue
V-Fib, V-FIB	ventricular fibrillation
VI	velocity index
VID	video
VNT	ventilator
VT	ventricular tachycardia

VTAC	ventricular tachycardia
V-Tach, V-TACH	ventricular tachycardia
VOL	volume
	W
WOB	work of breathing
WOBm	work of breathing (mechanical)
WT	weight
	X
X	multiplier when used with a number (2X); denotes invalid data when used in place of a value on the display

Symbols

12SL	12-lead ECG analysis
&	and
°	degree(s)
>	greater than
<	less than
–	minus
#	number
%	percent
±	plus or minus
µ	micro

For your notes

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For your notes

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